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SOIL STABILIZATION—

A SHORT COURSE

Based on Exhibit of U. S. Bureau of Public Roads Displayed at the Last Road Show

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PART IV

IN the first three installments of this series *Road Stabilization* was explained. It is one part of the more general subject, *Soil Stabilization.*

As explained before, soil test data yield information useful in the design of structures resting on or built into soil. Consequently, the subject of soil stabilization covers the application of those data in the structural sense.

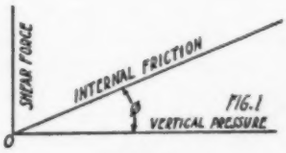


Fig. 1

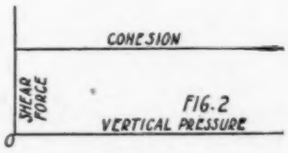


Fig. 2

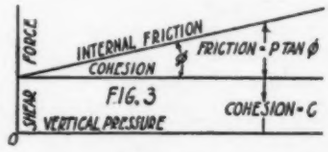


Fig. 3

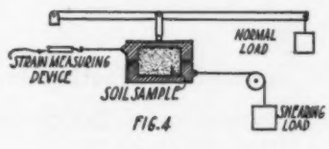


Fig. 4

All of the present knowledge concerning the shear strength of soils can be classified under two headings; that practical information which is utilized every day, in the construction of engineering works and those interesting theories from which it is expected that developments of a practical nature will be made in the future.

Because of the fact that shear test information is being used extensively in the design of structures it was thought that the practicing engineer would be interested in the resume of the testing procedures used by various laboratories and the method by which the results are correlated and utilized.

Conception of Shear Strength

The shear strength of a soil is the resistance of a portion of the mass to sliding along an internal surface. If we consider two wooden blocks as representing the two halves of a soil mass and the joint between them as a shear plane, the force needed to slide the upper block over the lower one would correspond to the shear strength of the soil.

Friction—Suppose the blocks were covered with sand-paper. When one block just lightly rests on the other one it can be slid along with very little effort. If, however, a load is placed on the upper block it is very difficult to produce sliding. This is the type of resistance offered by the sand friction of a soil and is termed "internal friction." Disregarding units for the moment, if we plot shear strength against the vertical pressure, for a sand, Fig. 1, we note that the friction increases with the increase in vertical pressure but is reduced to zero when there is no vertical pressure. The angle of internal friction, ϕ, is determined as shown.

Cohesion—If the blocks are covered, not with sand-paper, but with some sticky material such as vaseline or molasses, they will resist sliding even when no vertical pressure is applied and, furthermore, when the blocks are loaded the sliding resistance is practically unchanged. This type of resist-

ance is termed "cohesion" and is supplied by the glue-like colloidal material (clay) in a soil. A plat of shear strength against vertical pressure for a pure clay would be of the type shown in Fig. 2. Thus the cohesion would have a constant value regardless of the vertical pressure.

Shear—If the blocks are coated, first with sandpaper and then with vaseline or molasses, they will resist sliding when there is no vertical pressure and the resistance will increase as vertical loads are applied. This analogy represents the average soil that contains both sand and clay and whose shear strength is equal to the sum of the cohesion and internal friction. A plat of shear strength

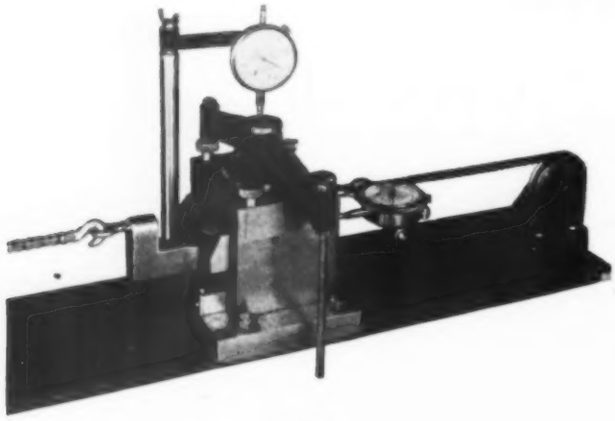


Fig. 5

against vertical pressure would assume the character of the curve, Fig. 3. Here we note that the cohesion, being independent of vertical pressure is the shear strength at zero load. The internal friction is zero at zero vertical pressure but increases as the vertical loads are applied. The total shear strength is the sum of the cohesion and the internal friction and is expressed by the following formula:

$S = p \tan \phi + c$, where
S = Shear strength
p = Vertical pressure.
ϕ = Angle of internal friction
c = Cohesion

Testing Procedure

Preparation of Samples—Since shear strength is a structural property of a soil mass, the samples to be tested must conform as closely as possible to the larger mass to which the test data are to be applied. If a foundation soil is being tested, an undisturbed core must first be obtained, and then a sample carefully cut out and fitted into the shear device. If the stability of an earth fill is to be determined, the samples must be at the same moisture content, and artificially compacted to the same density as the fill material.

Apparatus—There is no standardized shear test apparatus and it is improbable even that the types used in any two laboratories are identical. However, every device must have three essentials: a method of applying known vertical loads, a method of applying known shear loads in very small increments and a device for measuring the movements produced by shear loads.

The shear strength of other samples of the same material are then determined for different vertical pressures and the results plotted as shown in Fig. 9, a typical shear curve for dry sand. As discussed before, the angle of internal friction, ϕ, is determined as shown. By projecting this curve to zero vertical pressure, the shear strength is reduced to zero. This meets the condition previously described for fractional materials.

Figure 10 is a typical shear curve for a clay soil which contains a small amount of sand. The shear strength at zero vertical pressure is the cohesion supplied by the clay fraction. The increase in shear strength for different vertical pressures is attributed to the shear-component, internal friction, supplied by the sand. It will be noted that the angle of internal friction is less than that for the pure sand.

Structure of the Sample

The shear curve for dry sand is valid, regardless of the degree of disturbance of the sample, since such material does not have any natural "structure." However, such a curve for a clay soil represents the shear strength at just one density, moisture content and natural field environment; the original undisturbed state. Such information is sufficient for soils that are not subject to change in structure. If, however, the superimposed load will compress a foundation soil or if it is desired to know the shear strength of compacted soils varying in density, it is necessary to develop a set of relationships which will enable the correlation of the variables that are subject to change.

Shear-Compaction Relations

In the shear device designed by Mr. Preece (Fig. 5) the soil sample is placed between porous stones in an almost liquid state and is consolidated by a vertical pressure. By this arrangement the shear resistance can be determined for several different densities and the consolidation loads, densities and shear components can be correlated.

The testing procedure is similar to that used in other apparatus except that each sample is placed in the device at a moisture content above the liquid limit and a vertical load is applied until consolidation is complete. The shear strength is then determined under a vertical pressure equal or less than the consolidation load. The procedure is repeated several times using new samples and the same consolidation load applying different vertical pressures. A plat of shear strength for different pressures will have the form shown in Fig. 11.

By varying the consolidation loads but repeating the entire procedure outlined above a series of shear curves for different compaction loads can be obtained, as shown in Fig. 12. The shear strengths for the condition where the vertical pressure is equal to the consolidation load form the plat shown in Fig. 13. This curve represents the shear strength of soils under maximum density as defined by the Proctor tests (for different compaction or consolidation loads) and under conditions of complete saturation with respect to water.

The essential shear test apparatus is schematically represented in Fig. 4. The detailed apparatus used in the different laboratories conforms to this general design principle with possible variations in the size and shape of the sample, method of applying loads.

etc. A simplified apparatus used in the laboratory of the National Park Service (E. F. Preece, Ass't Chief Engineer) is shown in Fig. 5. A new "plate" type shear device recently developed by the Division of Tests, U. S. Bureau of Public Roads (E. F. Kelley, Chief of Division) and exhibited at the 1938 exhibit at the Convention of the American Road Builders' Association, is shown in Fig. 6.

Procedure—There are two general procedures which are described as follows: In the first a given vertical load is applied to the sample. Then shear loads are applied in increments at regular intervals

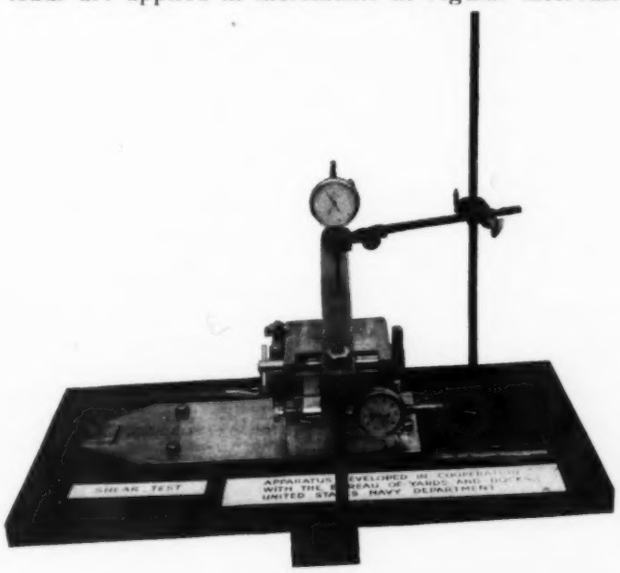


Fig. 6

of time, such as every minute. Deformations as shown by the micrometer dials, are recorded at given lengths of time after the addition of each increment of shear load. Thus, if shear loads are applied at 0, 1, 2, 3, 4, etc., minutes, deformations would probably be recorded at ½, 1½, 2½, 3½, etc., minutes.

The time-deformation data thus obtained is plotted as shown in Fig. 7. It can be seen that the deformation, expressed as a logarithm, increases regularly with time (and, hence, increased load) up to a definite maximum where failure occurs and deformation increases without limit. Since the increments of shear load were applied at regular intervals, a second linear plat (Fig. 8) can be made of shear force against the logarithm of the deformation. In this case, the point of inflection of the curve represents the shear strength of the sample under one vertical load.

In the alternate method of loading, the soil is allowed to come to equilibrium after each increment is applied and the final deformation recorded. The load-deformation curve is similar to Fig. 8.

Theoretical Considerations

Referring to Fig. 13 we note first of all that the shear curve for conditions of maximum density is exactly the same type of curve that was obtained for dry sand. We might define a new angle, Y, as the angle of internal stability, in which case

$S = p \tan Y$, where
S = Shear strength
p = Vertical pressure
Y = Angle of internal stability

We note, also, that the shear strength is zero when the soil has not been consolidated. This is in agreement with the theory since the soil was placed in the device above the liquid limit and should have no stability.

It will be noted, also, that the soil samples do not possess cohesion unless they have first been consolidated and then, without allowing more water to enter the samples, the vertical load is entirely removed. Thus, it seems probable that by allowing a wet soil to expand without increase in moisture content, the original films are "stretched" and the resulting tension is actually cohesion. This force might also be described as a "capillary pressure" as suggested by L. A. Palmer of the Bureau of Public Roads. The fact that the cohesion is zero when the soil is saturated suggests capillary pressure, since this property is also known to be zero under conditions of saturation.

It will also be seen that the angle of internal friction increases as the consolidation load is increased.

Interrelated Soil Properties

By the above procedure a series of structural properties of a soil have been evaluated for varying field conditions. By correlating these properties, as follows, it is possible to obtain a complete behavior pattern for a soil.

Moisture-Density—Mathematically and experimentally it has been found that under conditions of optimum density or saturation the density is inversely proportional to the moisture content (by volume) as shown in Fig. 14.

Density-Vertical Pressure—It has also been determined experimentally that the density to which soils can be compacted or consolidated is proportional to the logarithm of the applied vertical pressure, as shown in Fig. 15.

Vertical Pressure-Angle of Internal Friction—On the curve, Fig. 13, it was noted that the angle of internal friction increased with higher vertical pressures. As shown in Fig. 16, this relation is linear and there is a value of the angle corresponding to a zero vertical load. Perhaps this is an angle of rest of the material.

Vertical Pressure-Friction, Cohesion—From the plat, Fig. 17, we note that the logarithms of the cohesion and the internal friction are proportional to

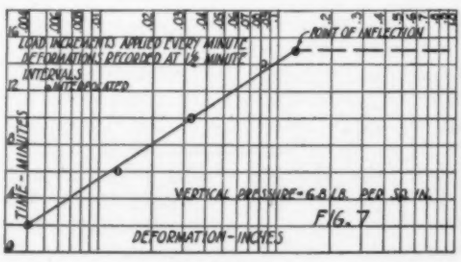

LOAD INCREMENTS APPLIED EVERY MINUTE
DEFORMATIONS RECORDED AT ½ MINUTE INTERVALS
POINT OF INFLECTION
TIME - MINUTES
VERTICAL PRESSURE-6.8 LB. PER SQ. IN.
FIG. 7
DEFORMATION - INCHES

Fig. 7

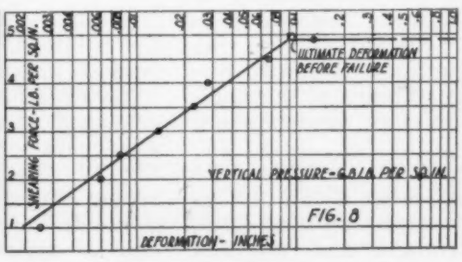

ULTIMATE DEFORMATION BEFORE FAILURE
SHEARING FORCE - LB. PER SQ. IN.
VERTICAL PRESSURE-6.8 LB. PER SQ. IN.
FIG. 8
DEFORMATION - INCHES

Fig. 8

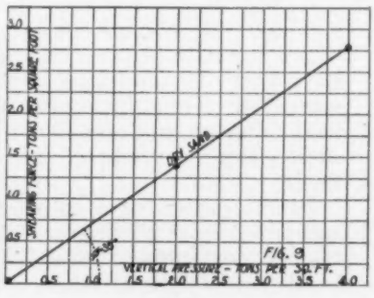


Fig. 9

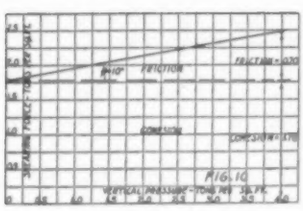


Fig. 10

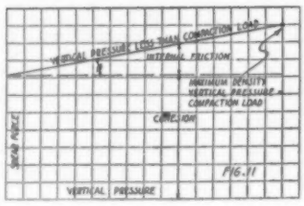


Fig. 11

the logarithms of the vertical pressure.

Cohesion-Friction—From the plat, Fig. 18, we note that the logarithm of the internal friction is proportional to the logarithm of the cohesion, as shown.

Summary of Relations

From the above curves it can be seen that under conditions of saturation or maximum density, considered to be representative of field conditions, the consolidation pressure, density, moisture content, total shear strength and the components, cohesion and internal friction are mathematically interrelated. Thus, from the above relations it is possible to predict the behavior of a soil for different field conditions.

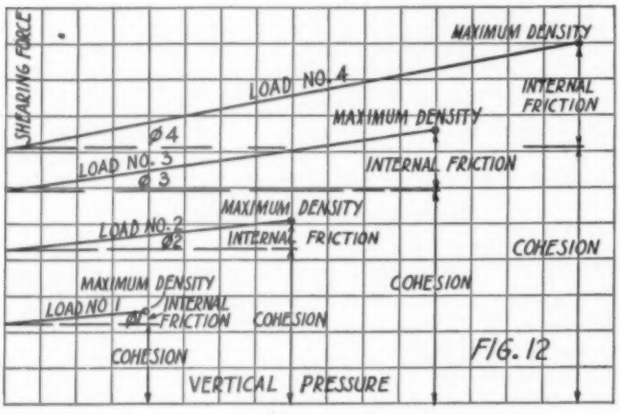


Fig. 12

Utilization of Data

We now come to the parting of the ways for the research workers interested in the theories underlying the above relations and the practicing engineer who wants to know how to use the information.

Nothing further will be said concerning the theoretical considerations except that information of this type opens up a vast field for the chemists, physical chemists and physicists as well as the soil technicians in the study of film phenomena, surface chemistry and basic properties of soils, and pure colloids, such as plasticity, hydration, gel formation, swelling, etc.

It is thought that the basic relations obtained by this test procedure are of interest to the practicing engineer in the following ways:

In foundation analyses the shear strength of the soil must be known, not only for the density at which it exists before construction, but also the density after consolidation after the erection of the structure. Thus, by correlating shear strength, vertical pressure, and density, the stability of the foundation can be predicted for different superimposed loads.

In the design of a rolled-earth fill the slopes are computed from shear test data. Also, it can be seen that a correlation between compaction pressures, available moisture, shear strength and required

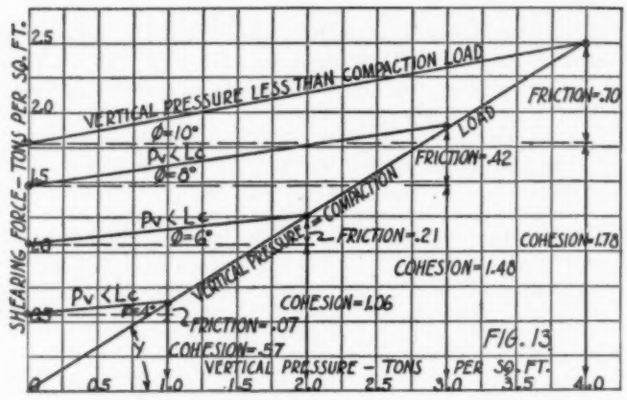


Fig. 13

slopes and volumes of earth will enable the most rational design from a standpoint of costs.

A study of the variations in shear strength due to normal changes in moisture content, density, etc., in the field should enable the intelligent selection of safety factors.

Design Problems

The application of shear test data in the field of design has ceased to become something "new" but is now considered to be a necessity. While it is not the purpose of this paper to discuss this phase of soil mechanics it was thought that the inclusion of several practical examples would be of interest.

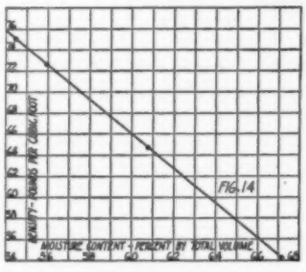


Fig. 14

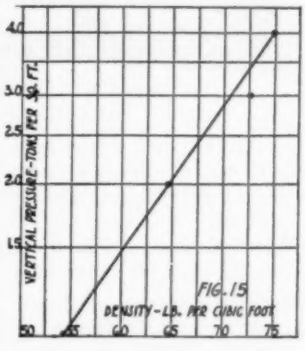


Fig. 15

These examples are taken from panels exhibited by the Division of Tests of the Bureau of Public Roads at the 1938 American Road Builders' Convention.

In these problems it will be seen that the shear tests are used, primarily to determine the values of the cohesion **c**, and the angle of internal friction ϕ.

Shear Strength Determines the Resistance of Soil to Lateral Displacement from Beneath Piers and Along Planes Beneath Abutments

The shear strength of the soil depends upon the cohesion **c**, the angle of internal friction ϕ, and the pressure **p**, upon the plane of shear, in accordance with the basic equation:

$$S = p \tan \phi + c \quad \ldots\ldots (1)$$

The soil must be deformed before shear strength is developed. In some soils, the horizontal deformations required to develop the ultimate shear strength indicated by test, causes the sample to be deformed as much as 60 per cent of its thickness. The characters of these deformations are shown in Fig. 19. Therefore, the ultimate c and ϕ determined by test cannot be used but instead values at which *allowable* deformations occur, and consequently relations of deformation to c and ϕ are necessary.

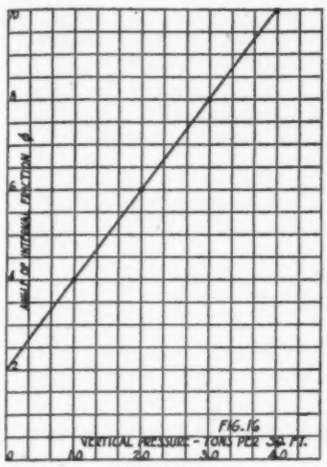


Fig. 16

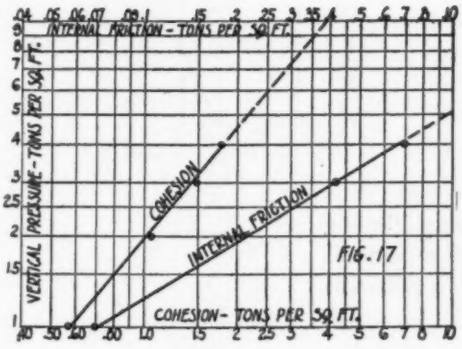

INTERNAL FRICTION - TONS PER SQ. FT.
VERTICAL PRESSURE - TONS PER SQ. FT.
COHESION
INTERNAL FRICTION
FIG. 17
COHESION - TONS PER SQ. FT.

Fig. 17

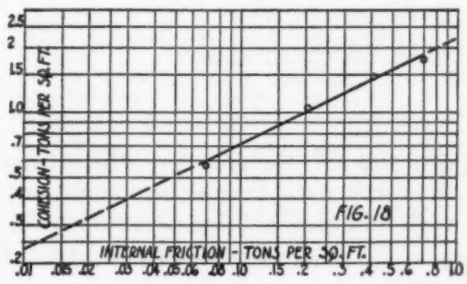


Fig. 18

For an accurate conception of the effect of the stress-strain relation the sample thickness may be taken into consideration by expressing the horizontal deformations as percentages of the vertical thicknesses of the samples between the edges of the fins or grids.

Fins and Grids—To distribute the shearing stress throughout the test sample in the shear box, a series of parallel metal strips (fins) are fixed perpendicular to the direction of movement in both the top and bottom of the box. The "Normal Load" causes these fins to cut into the sample before the "Shear Load" is applied.

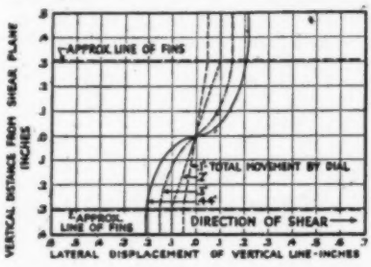

APPROX. LINE OF FINS
TOTAL MOVEMENT BY DIAL
APPROX. LINE OF FINS
DIRECTION OF SHEAR
VERTICAL DISTANCE FROM SHEAR PLANE IN INCHES
LATERAL DISPLACEMENT OF VERTICAL LINE - INCHES

Fig. 19

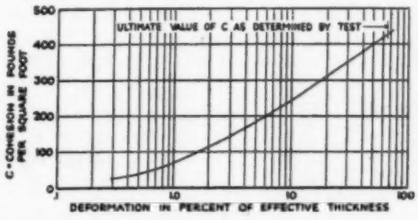

ULTIMATE VALUE OF C AS DETERMINED BY TEST
C - COHESION IN POUNDS PER SQUARE FOOT
DEFORMATION IN PERCENT OF EFFECTIVE THICKNESS

Fig. 20

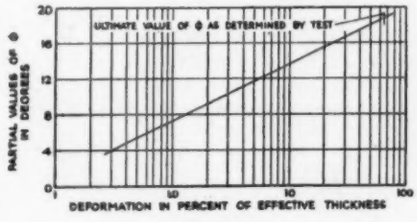


Fig. 21

The curves in Fig. 20 and 21 represent test values on a sample of clay soil 0.2 of an inch thick between fins; moisture content of 27 per cent; liquid limit of 43; and a plasticity index of 24. It is evident that the possible lateral displacement of a bridge abutment on a soil layer 6 in. thick might not be dangerous whereas the lateral displacement on a soil layer 6 ft. thick might be disastrous.

Maximum Shear Stress in the Subsoil Under Road Fills Is Equal Generally to 3/10 of the Unit Load (p) of the Fill at the Subsoil Surface Beneath the Roadway

In the diagram, Fig. 22:

P_1 = major principal stress at any point x.

P_2 = minor principal stress at any point x.

P_x = horizontal stress at any point x.

P_z = vertical stress at any point x.

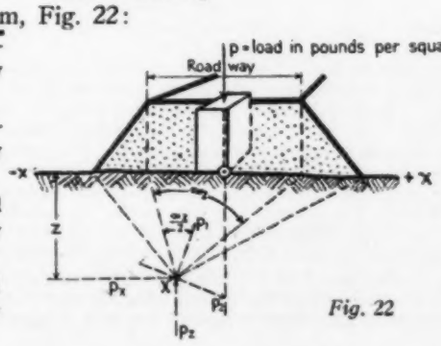


Fig. 22

The greatest value of s (maximum) $= 0.3\ p$.

Let P = vertical pressure of fill material in pounds per square foot at the subsoil level beneath the roadway.

w = weight of fill material in pounds per cubic foot.

h = height of fill in feet.

s = shear stress in pounds per square foot.

Then, $p = wh$ ..... (2)

For most fills it is safe to use the following formula:

Maximum shear stress in subsoil = greatest value of

$$S \text{ (maximum)} = \frac{3}{10}p \ldots\ldots (3)$$

Depth of the greatest shear stress below the ground surface varies with the angle of the side slopes of the fill.

Let x = any point in the subsoil.

R_1, R_2, R_3, and R_4 = radial distances in feet.

b = ½ roadway width in feet.

a = width of side slope in feet.

α_1, α_2, and α_3 = angles in radius between R_1, R_2, R_3, and R_4.

O = intersection of center line of fill with surface of subsoil.

OZ = center line of fill.

x = horizontal distance in feet from OZ to x.

z = depth from subsoil surface to point x.

s (maximum) = maximum shear stress in pounds per square foot at any point x.

When the greatest value of s (maximum) falls on the center line OZ where $\alpha_1 = \alpha_2$, $R_1 = R_4$, and $R_2 = R_3$, then $(\alpha_1 - \alpha_2)^2 = 0$; and the general formula

$$s \text{ (maximum)} = \frac{Z}{\pi}\frac{P}{a}\sqrt{\log_e^2 \frac{R_1 R_4}{R_2 R_3} + (\alpha_1 - \alpha_2)^2}$$

reduces to

$$\frac{2ZP}{\pi a} \log_e \frac{R_1}{R_2} \ldots\ldots (4)$$

Values of the maximum shear stress on OZ for two different degrees of side slope are shown in Figs. 23 and 24.

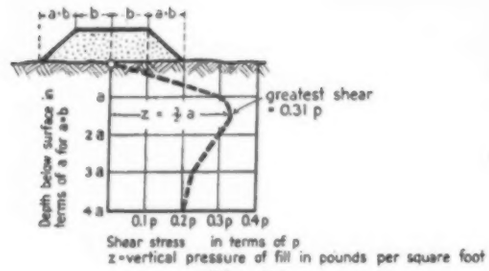


Fig. 23

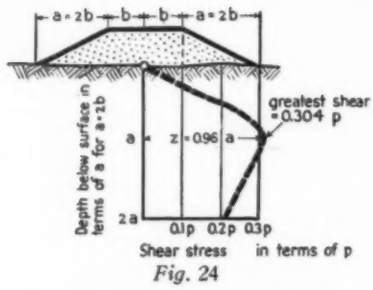


Fig. 24

Method of Determining the Supporting Power (Resistance to lateral displacement) of a Subsoil with a High Cohesive Strength Beneath a Fill with a Low Cohesive Strength

GENERAL FORMULAS

Let P_z = vertical stress at any point X resulting from weight of fill.
P_x = horizontal stress at any point X resulting from weight of fill.
P_1 = major principal stress at any point X resulting from weight of fill.
P_2 = minor principal stress at any point X resulting from weight of fill.
z and x = coordinates of point X.
s_{xz} = shearing stress in the vertical cross-section plane.

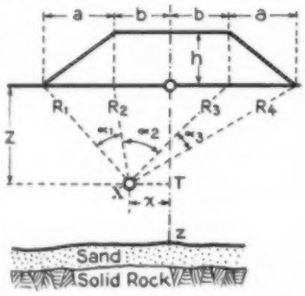


Fig. 25

s (maximum) = maximum shearing stress at any point X.

Then $$P_z = \frac{P}{\pi a}[a(a_1 + a_2 + a_3) + b(a_1 + a_3) + x(a_1 - a_3)] \quad \ldots\ldots(5)$$

$$P_x = \frac{P}{\pi a}[a(a_1 + a_2 + a_3) + b(a_1 + a_3) + x(a_1 - a_3) - 2z \log_e \frac{R_1 R_4}{R_2 R_3}] \quad \ldots\ldots(6)$$

$$s_{xz} = \frac{zP}{\pi a}(a_1 - a_3) \quad \ldots\ldots(7)$$

$$P_1 = \frac{P}{\pi a}[a(a_1 + a_2 + a_3) + b(a_1 + a_2 + x(a_1 - a_3) - z \log_e \frac{R_1 R_4}{R_2 R_3}] + \frac{zP}{\pi a}\sqrt{\log_e^2 \frac{R_1 R_4}{R_2 R_3} + (a_1 - a_3)^2} \quad \ldots\ldots(8)$$

$$P_2 = \frac{P}{\pi a}[a(a_1 + a_2 + a_3) + b(a_1 + a_3 + x(a_1 - a_3) - z \log_e \frac{R_1 R_4}{R_2 R_3}] + \frac{zP}{\pi a}\sqrt{\log_e^2 \frac{R_1 R_4}{R_2 R_3} + (a_1 - a_3)^2} \quad \ldots\ldots(9)$$

$$s\ (\text{maximum}) = \frac{zP}{\pi a}\sqrt{\log_e^2 \frac{R_1 R_4}{R_2 R_3} + (a_1 - a_3)^2} \quad \ldots\ldots(10)$$

SOLUTION OF A TYPICAL PROBLEM—First find the maximum shear stress on the center line OZ

Given—For fill:
w = weight = 90 pounds per cubic foot.
$a = b = h = 20$ feet $OT = 3/2\ a =$ 30 feet.
OZ = depth of cohesive subsoil = 50 feet.
$a_1 - a_3 = 0$ for all points on OZ.
P_z = vertical pressure in undersoil resulting from weight of fill.
c = cohesion = 200 pounds per square foot.
ϕ = angle of internal friction = 5°.

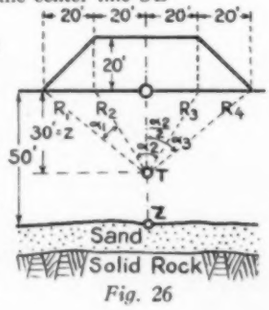


Fig. 26

For undersoil: $c = 800$ pounds per square foot. $\phi = 15$ degrees.

Now $R_1 = R_4 = \sqrt{(40)^2 + (30)^2} = 50$ feet and $R_2 = R_3 = \sqrt{(20)^2 + (30)^2} = 36.05$ feet.

Also $a_1 + \frac{a_3}{2} = \text{arc tan } \frac{40}{30} = \frac{53.1° \pi}{180} = 0.927$ radians and

$\frac{a_3}{2} = \text{arc tan } \frac{20}{30} = 0.588$ radians.

Thus $a_3 = 1.176$ radians and $a_1 = a_3 = 0.927 - 0.588 = 0.339$ radians.

Substituting in formulas (8) and (9). $\frac{P_1 + P_2}{2} = 889$ pounds per square foot at the point I.

Thus the shear strength at point T is $s = c + \left(\frac{P_1 + P_2}{2}\right) \tan \phi = 800 + (889) \tan 15° = 800 + 240 = 1{,}040$ pounds per square foot. Since the maximum shear stress, s (maximum), at point $T = 0.3 \times wh = 0.3 \times 90 \times 20 = 540$ pounds per square foot, and since this is less than the cohesive strength alone = 800 pounds per square foot, at point T, then the *subsoil is safe against failure by displacement.*

If, however, c for the subsoil instead of being 800 had been less than 540 pounds per square foot, then a further investigation of the subsoil would need to be made by the method of plastic equilibrium using Prandtl's formula:

$$q = (c \cot \phi + wb \cot \Delta)\left(\frac{1 + \sin \phi}{1 - \sin \phi} e^{\pi \tan \phi} - 1\right) \quad \ldots\ldots(11)$$

Where $\Delta = 45° \frac{\phi}{2}$

q = supporting power of the subsoil in pounds per square foot.

Method of Determining the Supporting Power (Resistance to Lateral Displacement) of a Subsoil with a Low Cohesive Strength Beneath a Fill of Adequate Cohesive Strength

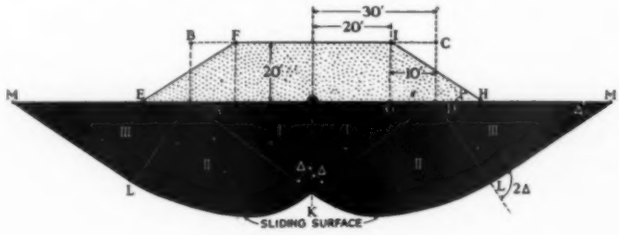


Fig. 27

Given: Draw a cross section $ABCD$ equivalent in mass and volume to the fill $EFIH$. Ground-water level at M-M with full hydrostatic uplift throughout the subsoil. The buoyed weight for a cubic foot of undersoil is $100 - 62.5 = 37.5$ pounds per cubic foot. Angle $\Delta = 45° - \frac{\phi}{2} = 42.5°$. c = cohesion = 200 pounds per square foot. Zone I moves down en masse. Zone II undergoes a combination of rotation and sliding along the log spiral KL. Zone III moves upward and outward, shearing along the plane LM. For stable earth fill of high shear strength $c = 800$ pounds per square foot and $\phi = 15°$. For subsoil with poor supporting power $c = 200$ pounds per square foot and $\phi = 5°$. w = weight of subsoil = 100 pounds per cubic foot. w_1 = weight of fill = 110 pounds per cubic foot. h height of fill = 20 feet. $b = 30$ feet $OK = b \cot \Delta = 30 \cot 42.5° = 30 \times 1.09 = 32.7$ feet. $wb \cot \Delta = 37.5 \times 32.7 = 1{,}226$ pounds per square foot.

In this case it is not safe to use the principles of stress distribution as applied to the subsoil with high cohesion under the fill of low cohesion. Here Prandtl's formula is approximately valid:

$$q = (c \cot \phi + wb \cot \Delta)\left(\frac{1+\sin\phi}{1-\sin\phi}\, e^{\pi \tan \phi} - 1\right) \quad \ldots\ldots (12)$$

Substituting: $q = ([200 \times 11.43] + 1{,}226)$

$$\left(\frac{1+0.087}{1-0.087}\, e^{\underset{\text{Naperian base}}{3.1416 \times 0.0875}} - 1\right)$$

$= 3{,}512\ (1.191 \times 1.315 - 1) = 1{,}990$ pounds per square foot

Bearing load $= wh = 110 \times 20 = 2{,}200$ pounds per square foot

Factor of safety of supporting value of subsoil $= \dfrac{1{,}990}{2{,}200} = 0.9.$

Thus the subsoil will fail by displacement.

For a factor of safety of 2: $\text{———} 2 = \dfrac{g}{wh} = \dfrac{1{,}990}{110 \times h}$ and $h = 9$ feet.

For a factor of safety of 1: $\text{———} 1 = \dfrac{g}{wh} = \dfrac{1{,}990}{110 \times h}$ and $h = 18$ feet.

Stability of Fills with Respect to Sliding May Be Determined by the ϕ - Circle Method

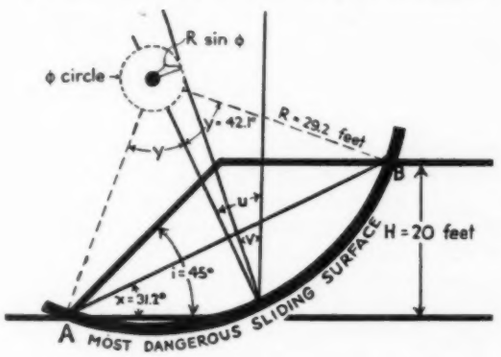


Fig. 28

Given for fill material.
c = cohesion = 200 pounds per square foot.
F = factor of safety against sliding.
ϕ = angle of internal friction = 5°.
i = inclination of side slope to the horizontal = 45°.
x = angle of chord of sliding circle with the horizontal.
y = ½ angle subtended by chord AB.
R = radius of the sliding circle.
H = height of fill in feet.
w = height in pounds per cubic foot = 90.

DATA ON CRITICAL CIRCLES COMPUTED BY THE ϕ-CIRCLE METHOD

i	φ	x	y	n	$\frac{c}{FwH}$
90	0	47.6	15.1	–	.261
	5	50	14	–	.239
	10	53	13.5	–	.218
	20	58	12	–	.182
60	5	38.5	34.5	–	.163
(45)	(5)	(31.2)	(42.1)	–	(.138)
30	5	23	48	–	.112
15	5	12.5	47	–	072

Fig. 29

General Formula—

$$\frac{c}{FwH} = \frac{\tfrac{1}{2}\csc^2 x\,(y \csc^2 y - \cot y) + \cot x - \cot i - 2n}{2 \cot x \cot v + 2} \quad (13)$$

where $n = \tfrac{1}{2} \cot x - \cot y - \cot i + \sin\phi \csc x \csc y)$ . . (14)

If after substituting the values from the table above in formula (14) it is found that n is negative or zero, then the dangerous sliding surface passes through the toe of the slope. The angles x, y, u, v, and i are shown in the figure above. From the above table F may be computed as follows:

$$\frac{c}{FwH} = \frac{200}{F \times 90 \times 20} = 0.138 \text{ or } F = \frac{200}{0.138 \times 90 \times 20} = 0.8$$

Thus the fill will fail by sliding.

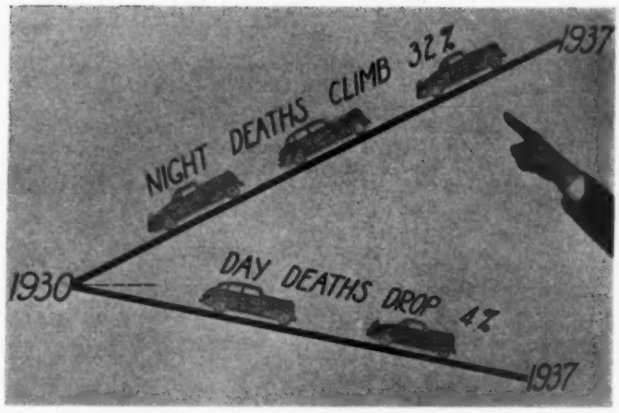
To overcome this tendency to fail either the angle of the side slope or the height of the fill must be *reduced*.

▼

World's Notable Cantilever Bridges

The following tabulation taken from the April issue of The Steel Constructor, a publication of the American Institute of Steel Construction, lists the world's notable cantilever bridges:

Location	Bridge	Date Completed	Main Span
Quebec	St. Lawrence River. Modjeski, Monsarrat, Schneider & Duggan, Engrs.	1917	1,800
Scotland	Firth of Forth (2 spans). Fowler & Baker, Engrs.	1890	1,710
California	San Francisco - Oakland Bay Bridge. C. H. Purcell, Ch. Engr. Dept. Public Works, State of California.	1936	1,400
Washington	Columbia River at Longview. Strauss, Engr.	1927	1,200
New York	Queensboro. Lindenthal, Engr.	1914	1,182
San Francisco, Cal.	Carquinez Straits (2 spans). Steinman & Derleth, Engrs.	1928	1,100
Quebec	Montreal Harbor. Monsarrat & Pratley, Engrs.	1929	1,097
Charleston, S. C.	Cooper River. Waddell & Hardesty, Engrs.	1929	1,050
Pittsburgh, Pa.	Monongahela River. Boller & Hodge, Engrs.	1904	812
Catskill, N. Y.	Rip Van Winkle. G. B. Woodruff, Engr.	1935	800
Lake Union, Seattle.	George Washington Memorial Bridge. Jacobs & Ober, Engrs.	1932	800
Coos Bay, Oregon	Coos Bay. C. B. McCullough, Engr.	1936	793
Memphis, Tenn.	Mississippi River. Morrison, Engr.	1892	790
New Orleans, La.	Huey P. Long Bridge over Mississippi River. Modjeski, Masters & Case, Engrs.	1935	790
Memphis, Tenn.	Mississippi River (Harahan). Modjeski, Engr.	1916	790
Beaver	Ohio River. Lucius, Engr.	1910	769
Mingo Junction	Ohio River. Boller & Hodge, Engrs.	1910	769
Sewickley	Ohio River. Chalfant, Gudmusson & Buel, Engrs.	1910	750
New York	Outerbridge Crossing over Arthur Kill. Waddell & Hardesty and O. H. Ammann, Engrs.	1928	750
Huntington, W. Va.	Ohio River. J. E. Greiner Co., Engrs.	1927	700
Bellaire, Ohio	Ohio River. J. E. Greiner Co., Engrs.	1927	700
Cairo	Mississippi River. Waddell & Hardesty, Engrs.	1929	700
New York	Goethals Bridge over Arthur Kill. Waddell & Hardesty and O. H. Ammann, Engrs.	1928	672
Thebes	Mississippi River. Modjeski & Noble, Engrs.	1905	671
Red Rock	Colorado River. Waddell, Engr.	1890	660
Charleston, S. C.	Town Creek. Waddell & Hardesty, Engrs.	1929	640



Night Traffic Accidents Alone Kill in the Neighborhood of 24,000 *Annually. Day Traffic, Though Three to Four Times Heavier, Is Responsible for* 16,000 *Deaths.*

LIGHTING THE NIGHT ACCIDENT ZONES

By T. W. DANA

Illuminating Engineering Laboratory, General Electric Co., Schenectady, N. Y.

OF all points along a highway system, intersections, pronounced curves, underpasses, and similar areas impose the greatest hazards upon safe traffic flow, especially at night when visibility is at a minimum. These locations or sections of highway might well be termed "night accident zones," and as such deserve greater illumination emphasis than may be justified along other straight sections of highway. Certainly they should be investigated and, if the hazard at night is noticeably greater than that by day, they should be illuminated. Adequate safety lighting saves, both in life and money, far more than it costs.

The following data have been compiled for the purpose of rendering definite assistance to highway engineers and others in applying adequate highway lighting equipment to these more hazardous sections of a highway system.

Recommendations for Applying Safety Lighting

The sodium-vapor lamp, aside from being a more efficient medium of light generation, has a characteristic amber color which especially recommends it for application to hazardous areas. Motorists proceed with greater care when approaching an area made visible by this cautionary illumination.

The recognized spacing of from 200 to 250 ft. per sodium luminaire, for straight sections of 2 and 3-lane highways, should be reduced to from 75 to 150 ft. linear for such danger zones. Irrespective of an intersection, curve, or straight-away section, these luminaries should be mounted approximately 25 ft. above the pavement on a bracket arm which will extend the unit from 3 ft. to 6 ft. over the edge of the pavement. This location insures a maximum of pavement reflection, with a minimum of glare, which is so essential to good visibility.

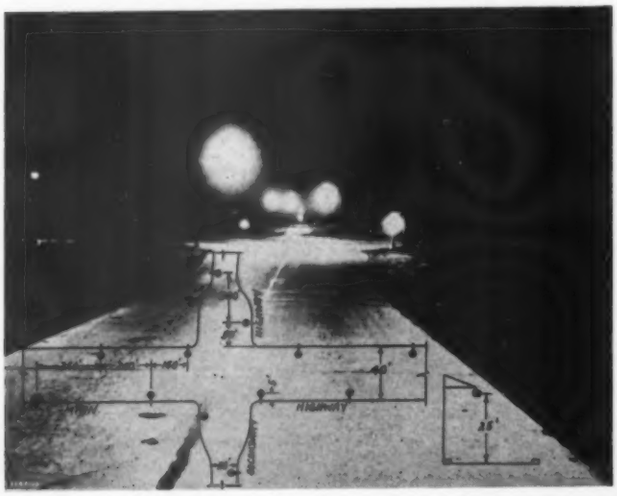


Fig. 1*—Right Angle Intersection on Skokie Valley (Illinois) U. S. Route* 41. *Illuminated with* 10,000 *Lumen Sodium Luminaires*

Typical Right Angle Intersection of a Main Secondary Highway

Such intersections are commonplace and in many instances have such inconspicuous signs that at night they are difficult to observe. Consequently, they are

Fig. 2*—Intersection of Routes* 33 *and* 34, *Asbury Park, N. J.*

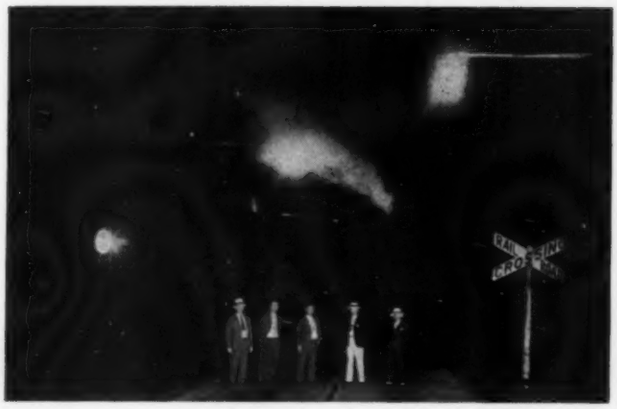


Fig. 3—Grade Crossing on Route 40 at Lewisburg, O.

usually points of high accident frequency. The sodium lamp with its characteristic yellow color is effective as a protective medium for this type or zone. Not only does it serve as a warning but the illumination of such points enable motorists to read signs and see pedestrians crossing at intersections. The high visibility enables the driver to act without indecision, and eliminates the groping around at night which is highly conducive to accidents.

Figure 1 shows such an intersection near Chicago, illuminated with sodium luminaires with 10,000-lumen lamps. The diagram gives the lamp spacing and arrangement for adequate illumination of such intersections.

Lighting Highway Tangential Intersections

Tangential intersections of secondary roads with main highways at curves present another type of "night accident zones." Incandescent shielded equipment, with 4,000-lumen lamps, is recommended to differentiate the secondary intersecting roadway from the main traffic artery.

When the curve is sharp the luminaires should be mounted on the outside of the curve; this is particularly true for the narrower two and three lane roadways. The average linear spacing for the pronounced curves should be reduced to 125 or 150 ft. per luminaire at the danger point, and gradually tapered off on either side to 200-250 ft. and staggered on either side of the roadway.

Figure 2 gives a typical application of this principle at a New Jersey intersection. The main highway is illuminated with the sodium luminaire with 10,000 lumen lamps. The secondary highway is distinguished from this, and at the same time given proper illumination emphasis, by use of incandescent shielded equipment employing 4,000-lumen lamps. These equipments are designed for 125-ft. linear spacing with a 25-ft. mounting height and mounted on one side of a 20-ft. roadway overhanging the pavement 5 ft.

Lighting of Railroad Crossings

The need for lighting at these particularly hazardous points is strikingly borne out by the following statement issued by the National Safety Council:

"There were 3,792 grade crossing accidents involving motor vehicles in 1936. Of these, 1,878 occurred in the daytime and 1,914 at night. This is almost an even split of the total, but note the following differences in circumstances: In about 1,800 of the day accidents the auto was struck by the locomotive, or ran into it; at night there were only 1,140 such accidents. On the other hand, there were only 80 (4 per cent) daylight accidents in which the automobile struck some part of the train behind the locomotive, while there were 770 (41 per cent) of these accidents at night (despite less

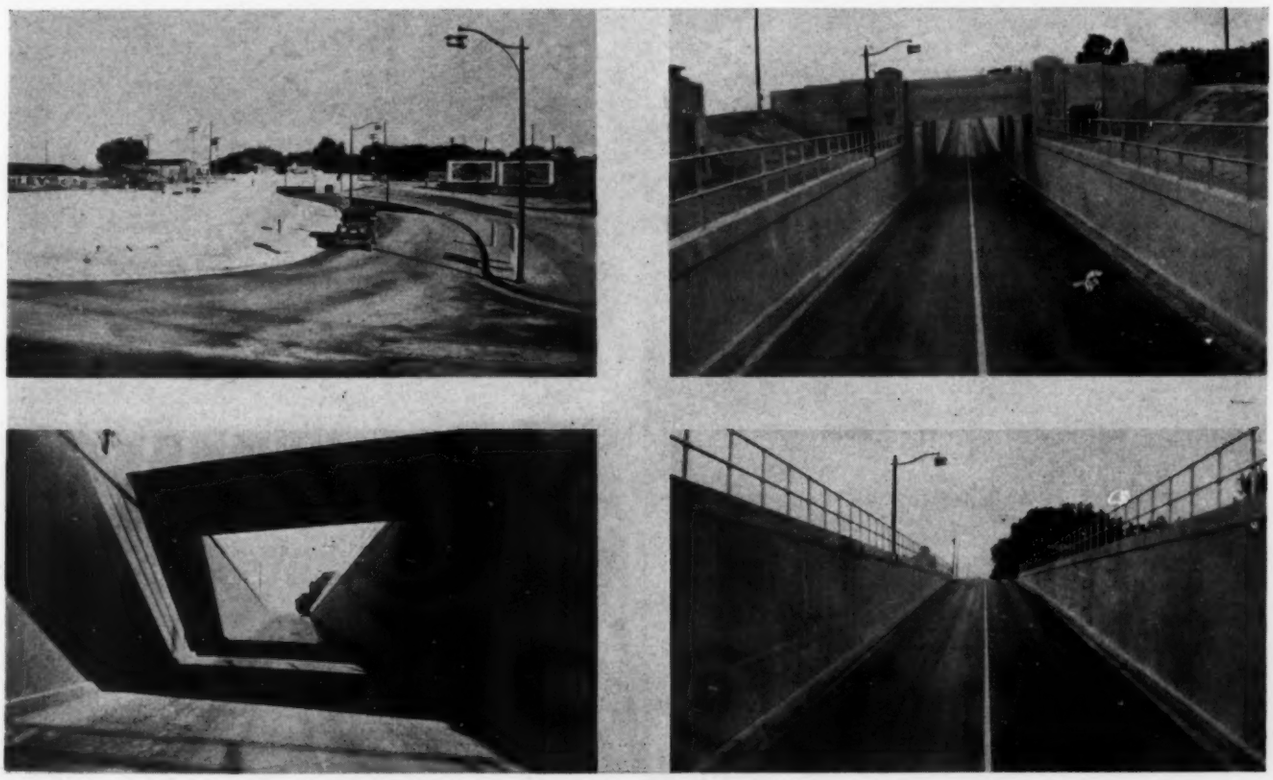


Fig. 4—Four Views of Highway Underpass at Las Vegas, Ne vada

night traffic). Inasmuch as most night accidents of this character involved freight trains or switching operations *it appears likely that the principal cause was lack of illumination.*"

A practical application of illumination to such a danger point is shown in Fig. 3. Sodium luminaires (either series or multiple) equipped with 10,000-lumen sodium lamps are mounted on a steel or wood pole at a height of approximately 25 ft. to light center. The luminaires should be mounted 5 ft. over the edge of the pavement and located 40-50 ft. on either side of the crossing. The indicated arrangement of luminaires produces maximum visibility; the distinctive color serves as a warning by attracting attention.

Underpasses and Overpasses

In many places dangerous railroad crossings on main trunk lines have been eliminated by expensive and elaborate underpasses or overpasses. Nevertheless many of these points where grade crossings have been eliminated continue to be hazardous. This is because many embody curves, or are narrow, or are points where fog tends to collect. The expense of illuminating these danger zones is small compared with the cost of eliminating the crossing and they are thus transformed into 24-hour safety zones.

Fig. 5—Curve and Underpass Near Cherry Valley, N. Y. U. S. Route 20. Illuminated with 10,000 Lumen Sodium Luminaries.

Fig. 6—North Approach of Poplar-Beckan Overpass at Tyler, Tex.

Fig. 7—Underpass at Sacramento, Calif.

The design and construction of these underpasses are so varied that it is hard to set down a general example for their illumination. In general a unit positioned on either side of an underpass of average width will serve as warning to approaching motorists. However, many of these underpasses have long, irregular approaches and in order to do an adequate job of safety lighting, additional units are necessary. The illustrations shown give several examples, (Figs. 4-7.)

Dangerous Curves

Abrupt curves simliar to that shown in Fig. 8 present a serious hazard at night, especially on express highways. The motorist traveling these routes is not warned of the impending danger in sufficient time to overcome the various physical factors involved. If on the other hand, these road conditions are revealed at

Fig. 8—Balltown Road, Schenectady, N. Y.

night as they are in the daytime, several thousand feet ahead, one has ample time to slow down and meet these hazards at a safe speed.

The illumination provided on this stretch of two lane highway shown in Fig. 8 is a striking illustration. This curve is illuminated with a high-visibility incandescent lighting unit which employs a 4,000 lumen bar filament bi-post lamp. The luminaires are mounted 125 ft. apart, 25 ft. high and overhang the 20 ft. pavement by 5 ft. This overhang affords better visibility, especially at times when the pavement is wet. Once again it should be emphasized that the lighting units are mounted on the outside of the curve so that the light emitted from any one unit intercepts the greatest possible portion of the pavement.

Traffic Circles and Cloverleafs

In some instances dangerous right angle intersections of two heavily traveled routes have been made safer by the construction of traffic circles and cloverleafs. Although such an improvement eliminates certain types of accidents, confusion is often introduced by the complexity of the system. Such areas often introduce an additional night hazard as the motorists may run upon these without warning. Then, too, once he has entered the area he is handicapped by poor visibility and is unable to read road signs as quickly as he should, which adds to his confusion. Illumination of such areas will eliminate these hazards.

In Fig. 9 we have a good example of such an intersection improvement near Troy, N. Y. This circle is illuminated with 10,000 lumen sodium lamps in shielded luminaries. The layout is indicated by the diagram superimposed on Fig. 9.

In Conclusion

Research and engineering developments have greatly increased the efficiency of light sources during the last few years, and improvements in materials and design have made possible the construction of luminaires that more accurately control the distribution of the light flux and produce higher utilization (effective light on roadway) efficiencies. Light sources available today and suitable for highway safety lighting are the incandescent and gaseous discharge lamps. Each has its field of application, and a study of local conditions and requirements will usually determine the type best suited for any particular installation.

Opportunity to observe road lighting in operation has also increased rapidly in the last three years. Sections of lighted roads are available for observation in nearly every part of the country. New installations are increasing the distribution every month and most road engineers do not have to travel far to inspect a lighted road.

Highway safety lighting has now become a vital part of a well-balanced program for correction of the night traffic problem which will not continue to be overlooked. Its incorporation, along with other improvements necessary for the handling of traffic safely and efficiently, is evident.

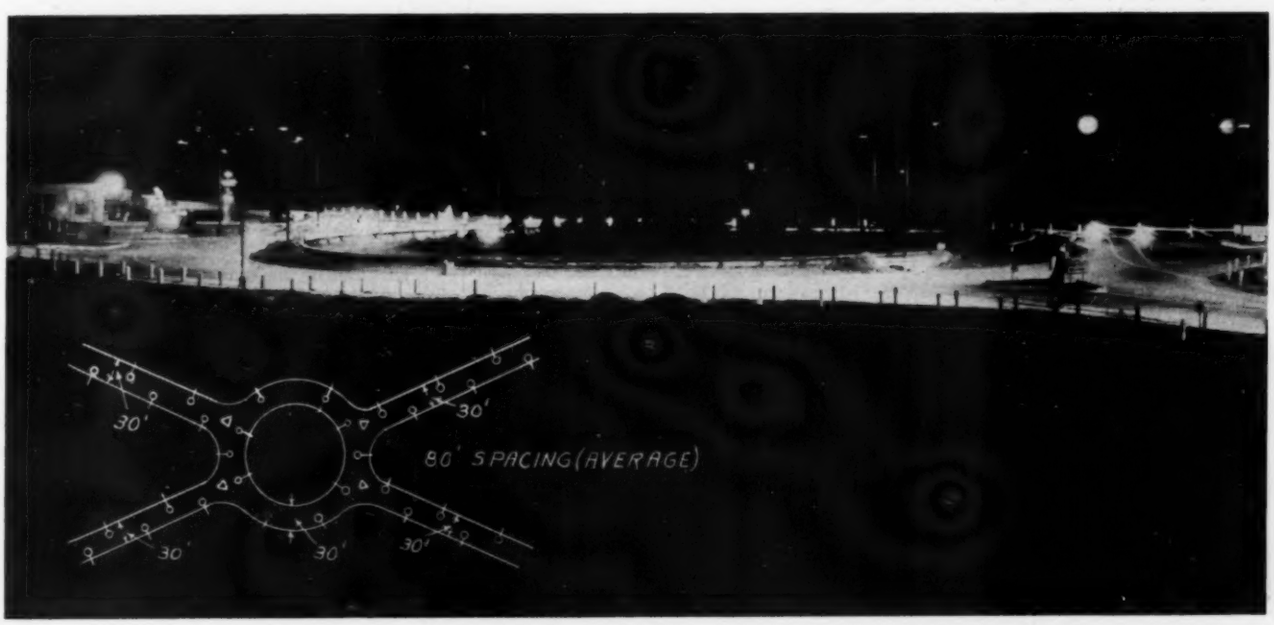


Fig. 9—Traffic Circle Near Troy, N. Y. Illuminated with 10,000 Lumen Sodium Lamps

PAVEMENT SURFACE IRREGULARITIES STUDIED

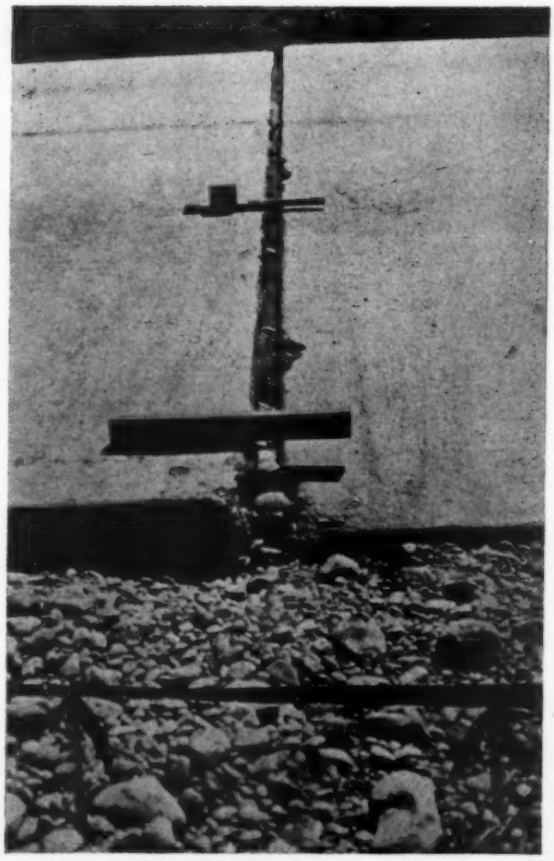
Texas Research Project Furnishes Voluminous, Continuous, As Yet Undigested Data

By JULIAN MONTGOMERY
Texas State Highway Engineer, Austin, Texas

SMOOTH riding surfaces that stay smooth after construction and last for many years are the goal of the highway engineer. The problem of retaining smooth riding qualities is difficult of solution. Many investigators have studied and are still studying various divisions of this problem.

As a part of the Texas State Highway Department's campaign of research to determine the causes of the development of uncomfortably riding, and at times dangerous, irregularities which develop in pavement surface, and to find (if possible) practical solutions of the problems, an experimental project was made out of a concrete paving job approximately 4 miles long in the south-central part of the state. Surface irregularities have developed on some sections of all types of pavement in Texas. The state, however, has many miles of excellent paving of all types. In the case of concrete pavement it was observed that irregularities appeared, not at random, but under certain specific conditions. Therefore, it was thought that information could be quickly and definitely gained by a research project in which the development of these surface irregularities could be accuruately and continuously observed. As a consequence, the project constructed was varied in many features of design and construction procedure, and the general information desired was: (1) whether the trouble could be charged against the design and construction of the pavement proper, or (2) the non-uniform movements of the foundations, and (3) ways and means of overcoming the defects. It was also thought that if the trouble was found to be in the foundation of the concrete pavement, the knowledge gained would then apply to all other types.

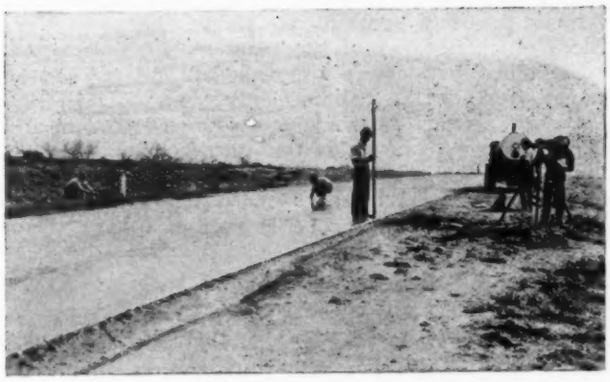
Bound Research Report



Showing How One Slab Would Move Past Its Neighbor. The Gravel on the Edge Is Surface Maintenance Material.

Since the project was in the nature of a general hunt, rather than an investigation of a particular point, it was considered of paramount importance in the preparation of the schedule of observation to be made that records of physical data be kept which might in some way or other have a bearing on the problem. It was, of course, preferable to have more data than might prove to be useful rather than fail to take certain records which later study might show should have been observed for determination of definite and satisfactory conclusions.

On this project, observations cover a period from date of construction in 1933 of the various sections to Oct. 21, 1934; from Oct. 21, 1934, to Oct. 21, 1935; from Oct. 21, 1935, to Oct. 21, 1936; and from Oct. 21, 1936, to Oct. 15, 1937, for certain observations. All



Taking Measurements to Determine Vertical Fluctuations. A Piano Wire Is Stretched Taut Across the Surface for Taking Measurements.

statistical research data have been compiled and arranged in four separate volumes corresponding to the periods of observation just mentioned. No intensive detailed study has as yet been made of the compiled data for the purpose of setting out definite conclusions.

One research engineer spent over four weeks' time studying the relationship of subgrade moisture content to slab fluctuations, so it can readily be seen that a great deal of time will be required for study before final conclusions can be obtained.

As one scans over the voluminous data several thoughts come to mind of its usefulness, to cement manufacturers, to steel reinforcement manufacturers, to joint manufacturers, to college professors for possible use by students for the preparation of theses, to highway construction and design engineers, to drainage engineers, to soil technologists, to aggregate producers, to pump manufacturers, to asphalt producers, and to grading equipment manufacturers.

The data are so well compiled that students who have to prepare theses could take the four volumes and by selection of certain relationships for study, deduce definite conclusions or suggest further indicated observations. In this activity these compiled data should find favor. It is not often that approximately a half million dollars is spent on a research project as detailed as this one, a project in which all field work is tabulated and classified and which covers a continuous three year period. Already savings effected on new construction from information obtained during this investigation have more than paid for the cost of the project.

Showing Compiled Data as Published

The project is located on U. S. No. 90 between the city of Sequin and Cibolo Creek in Guadalupe County, Tex., a distance of 13.539 mi. Average traffic is estimated at 3,500 vehicles daily.

Cause of Investigation

In 1928 it was noted that surface irregularities had developed on concrete pavements in different areas of Texas. At that time, measurements disclosed that the ends of slabs, at joints and cracks, had risen above the surface to produce longitudinal warping of the slabs. The warping was observed only on some sections of certain highways. These observations led to investigations and comparisons of data from different parts of the state and at that time revealed three things in particular:

1. No irregularities had developed on sand foundations.
2. Such warping as existed had occurred on clay soils (A6 and A7).
3. The major portion of the irregularities developed in cuts, on hill slopes and crests.

In 1932, the Texas Highway Commission, Mr. Gibb Gilchrest, then Chief Engineer, outlined the following general plan of investigation:

1. A complete study, utilizing all available technical and practical information, augmented by an experimental construction project awarded to contract on plans and specifications drafted for this express purpose, which would embody all possible designs that might throw light on the subject.
2. The selection of a location where the natural soil and climate conditions were similar to those where pavement in Texas had warped, and where local materials were economically available.
3. The compiling of costs of the different designs involved for comparative purposes.

The design features were to be arranged in accordance with the following plan:

a. Subgrade design variations
b. Concrete design variations
c. Length of slab variations
d. Reinforcing steel variations
e. Thickness of slab variations
f. Waterproofing of the bottom and sides of the slab.

There were no data available upon which to base any design from positive previous experience. Therefore, the designs finally adopted and awarded to contract were based entirely on technical analyses tempered with practical experiences previously encountered in the field in Texas. The project was divided into 37 separate test sections and two regular sections. The plans embodied 12 different designs of slabs, 7 different mixes of concrete, and 18 different types of subgrade treatment, in such order and sequence that possible warping could be compared. The type of concrete design adopted for all sections, except where modified for special reasons, was the regular Texas concrete design of 5 sacks of cement and 29 gal. of water per cubic yard of concrete. The ponded water curing method was used throughout. Except where modified, the slab lengths between poured expansion joints was 78 ft. 6 in. with one surface dummy joint at the midpoint thereof. Edge bar steel was cut at the expansion joints, but not at the dummy joints.

Data Obtained

A portable field office housed the special testing equipment. The data compiled included the following field investigations coordinated with laboratory analyses:

Sampling the Soil Subgrade for Soil Constant Tests.

1—Description of construction methods; 2—Paving construction progress data; 3—Subgrade moisture contents; 4—Class and character of soil foundations; 5—Vertical movements of the pavement; 6—Progressive pictures of construction methods and observations; 7—Concrete design and strength data; 8—Detailed cost data; 9—Fluctuations in width of expansion joints; 10—Meteorological data; 11—Slab temperature fluctuations; 12—Slab condition surveys; and 13—Miscellaneous data.

Construction

Earth grading was begun on Jan. 27, 1932. During construction, particular emphasis was given to artificial compaction of the embankment. Each sectionized description sheet records the construction methods of that particular section. During the 4½ months lapse in construction, a very small amount of rainfall was recorded and only occasional blading was necessary for proper maintenance.

Observations

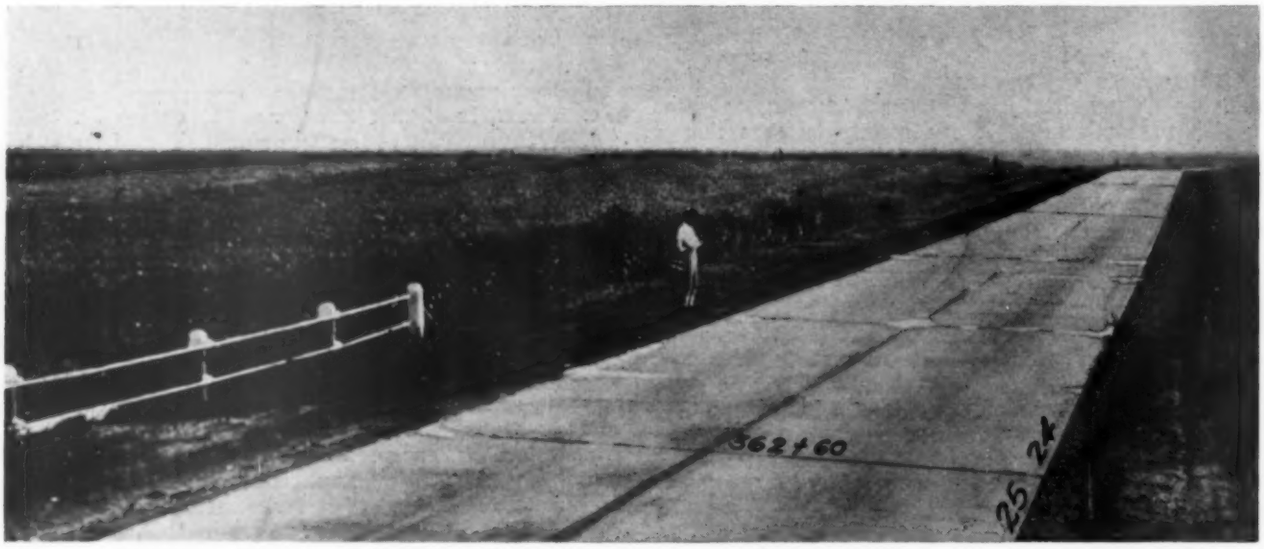
Soil moisture samples of the foundation were taken at prepared places at specified intervals of time as shown by the sectionized "soil data" sheets. Prior to dumping concrete on the subgrade (referred to as "just before" or the "soil data" sheets) 6-in. diameter handholes with water tight screwed covers (referred to as "manholes" or "hand holes") were set at selected established points and finished into the pavement. Through these the subgrade soil samples were obtained. All of the soil test constants determined are indicated in appropriate tables and charts. Elevations of the slab were taken at identical points on the slab each time. The profile elevations obtained certainly show how the slab curls, settles, or raises and causes uncomfortable riding. The record of cracking shows interesting relationships; the most striking of which is that for the section with dummy surface joints spaced at 10 ft. intervals, as yet there are no visible cracks in the slabs.

On the sectionized Road Condition Survey sheets, the road condition is shown in graphic form. In order to determine the pressure that exists, from time to time, between the concrete pavement slabs and different types of foundation soils, pressure cells of the "Goldbeck" type were installed 5 ft. to the right and 5 ft. to the left of the center line, also at the ends, quarter points, and mid-points of some of the slabs. The cells were placed on three types of subgrades.

Reference marks were also included and checked by transit to record any sliding or creeping of the slab that might appear. A tabular record of the sections and their variations, known as the Identification Sheet, is placed in the front of each volume. At the end of each volume of the research reports is a resume of indications observed for the period covered by that volume. Following is the resume of Volume I.

Resume of Volume I

It will not be attempted at this time to forecast the ultimate efficiency and practicability of the various designs employed on this experimental project. Sufficient time has not elapsed for the project to have undergone the complete cycle of climatic conditions. As yet, the project has been subjected only to an extremely dry period of weather. Therefore no indications can be obtained until after a long period of slow rains have occurred to complete the foundation moisture content cycle.



Ground Water Seepage Through Joints and Cracks; Sec. 24.

1. The subgrade moisture content at and near the 36 in. depth has remained relatively constant.
2. Transverse cracks have not appeared on sections having 3 dummy joints and 7 dummy joints.
3. Comparatively few cracks have developed on the 10 in., 8 in., 10 in. pavement cross-section.
4. Numerous cracks appeared during the prolonged dry summer season of 1934.
5. Vertical displacement at dummy joints has been negligible.
6. Sections No. 11 and 12 were decidedly more difficult to finish. These are high voided sections.
7. On Sections No. 13 and 14 numerous transverse cracks appeared at an early period. During construction an inadequate water supply system retarded normal progress from time to time.
8. Open cracks have not appeared on the sections with mat steel.
9. Excessive washing of the slopes was noted, and considerable blading was required to maintain the shoulders and slopes in satisfactory condition on Sections No. 25 and 27.
10. No appreciable shrinkage or displacement of the shoulders below that of the pavement elevation

and the absence of shrinkage cracks was noted on the sections having caliche or caliche gravel shoulder treatment.

11. A surface examination disclosed slight indications of wear on the low cement factor and on the low density sections of pavement.
12. On the low density concrete sections, the core strengths exceeded that of the cylinders. On the remaining sections, the condition was reversed.
13. The strengths on the high voided sections were consistently lower than the low voided sections with equivalent cement factor, except on the low density sections.
14. Shoulder soil shrinkage cracks appeared on sections having untreated shoulders, during the prolonged summer drought period of 1934. From Section No. 5 to Section No. 13, inclusive, this condition was excessive, while on the remainder of the sections the condition was not so pronounced; particularly was this true on the east end of the project which was subjected to a greater amount of shoulder traffic. Excessive shoulder and slope washes occurred between Sections No. 5 to 13, inclusive, following a dry period of weather.
15. Noticeable shoulder displacement occurred on the untreated types during a dry period. After a wet period, the condition was more pronounced where the pavement gradient exceeded that of the shoulder slope.
16. The melting point of the OA-55 oil asphalt, as placed in the joint, ranged from 129° F. to 132° F. Recorded slab thermometer readings show that the pavement reached and sometimes exceeded that temperature.
17. Fluctuations in temperature of the top of the pavement are more instantaneous and pronounced than that of the bottom.
18. The temperature of the subgrade, and top and bottom of the pavement tend to become equalized during low wet isothermo-chromal conditions.
19. OA-90 oil asphalt mats, when placed directly beneath the pavement or in the subsoil below, have a tendency to "bleed" to the surface, particularly on the shoulders and slopes. In the case of Section No. 32 where the pavement was placed directly on the mat, oil asphalt also appeared on the surface of the pavement through the joints and center plane.
20. Pulverizing air dried clods was not satisfactorily accomplished with power equipment coupled to a blade, scarifier, tooth-harrow, or disc-harrow.
21. Although reinforced bituminous paper was placed on two sections, no mixer delays resulted therefrom.
22. On several sections, the pavement was placed on a foundation in which a 6-in. layer of sand was built between two layers of clay soil. The upper 6 in. clay layer was placed directly beneath the pavement. No appreciable surface irregularities have developed.
23. Manipulation or the handling of concrete was considerably reduced on the low density sections.

Applying Asphalt Mat to Subgrade on One Section Before Placing Concrete.

Part II.—This volume contains the compiled data that are a continuation of Part I, and cover the period Oct. 21, 1934, to Oct. 21, 1935.

Resume of Volume II

Resume Volume II, Oct. 21, 1934, to Oct. 21, 1935.—The free water which seeped up through "dummy" joints and trickled down the pavement surface after long periods of slow rains, on Sections Nos. 13, 14, 23, 24, 25, 31, and 37 as heretofore mentioned, was never seen on any of the other test sections. Sections 36 and 37 were designed and built alike in every respect except that the 12 in. depth of sand under the pavement on Section 37 was placed in a trench cut in the native clay soil, while that on No. 36 was placed as a blanket entirely across the crown of roadway, to intersections with the side-slopes. Tests showed that the French drains on Section No. 37 did not function even when water was standing in the handholes and was passing up through joints and trickling along the pavement surface. At these same times, no water could be found in any of the handholes on No. 36, but it could be seen that the sand blanket was draining water to the side-slopes of the roadway.

No underlying fissures or wet-weather springs could be found on Section No. 37. It was noted that the seepwater rarely appeared on the pavement surface in the

Asphalt Seeped to Surface from Base Through Joints and Dummy Joints.

forenoon. At first it was thought that the traffic might be heavier in the afternoon and cause the phenomenon. While the daily traffic counts were being taken, the elevations of the water surface in the handholes were recorded, but no relation appears between that platted data. Coincidentally, the continuous self-recording three-bulbed thermometer was operating on Section No. 37 at the time. One bulb was in a brass tube 1 in. below the top of the concrete slab, one was 1 in. above the bottom of slab, and the other was in the sand directly under the slab. The platted data indicate that the elevation of the freewater under the pavement on Section No. 37 fluctuated with the temperature of the sand and water.

It was also observed that when free water was seeping through pavement joints and trickling along the surface, water did not flow out of an open handhole at a lower elevation in the pavement on the hill.

No doubt there is considerable difference in the amount of wetting of the soil foundation from rapidly falling and from slowly falling rains. The rain gauges do not record the rate of precipitation. This data can be very closely estimated from the relative humidity charts, with those of the temperatures of the atmosphere, and the top and bottom of the pavement. Although these latter data were recorded at only one place on the project at a time, when the long periods of slowly falling rains occur, they usually uniformly extend over the entire project.

The sudden cooling of the top of the slab from 116° F. to 102° F. in 50 minutes, by the application of water to its surface caused small changes in the elevations of the slab surface.

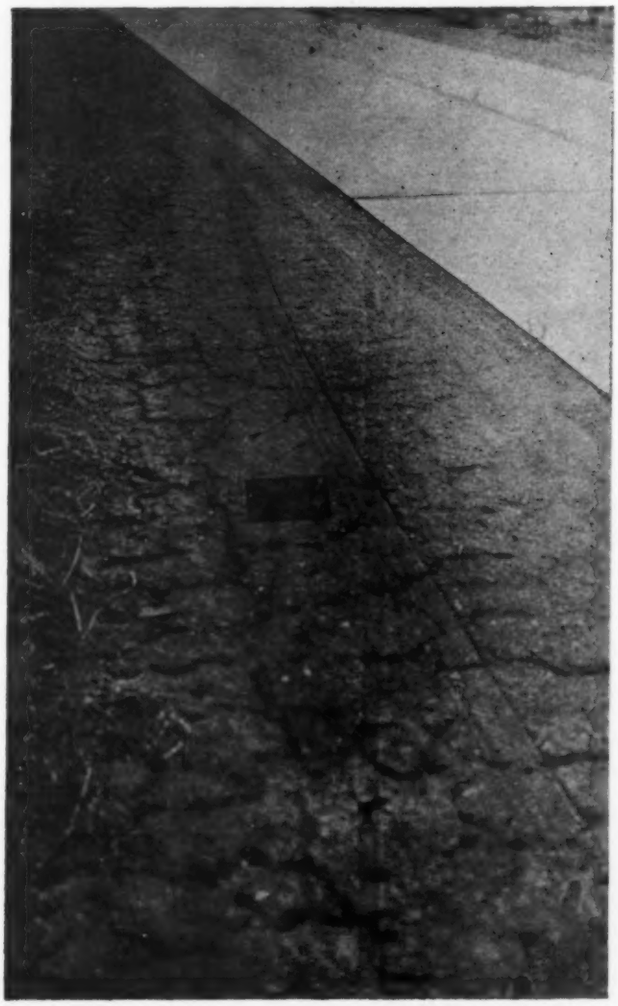
On the entire project, comparatively little additional cracking of the pavement developed during this period.

Although it was not mentioned in the Resume of Part I, much more transverse cracking developed in the concrete on Sections 9 A-B and 10 A-B than on Sections 11 A-B and 12 A-B.

Resume of Volume III

Resume, Vol. III, Oct. 21, 1935, to Oct. 21, 1936.—Some of these data may be used to advantage immediately by design engineers confronted with conditions similar to those on some of these test sections. Several of the reactions observed while taking the data were so outstanding that the phenomena have been used in the design and construction of later built highways in Texas. Conclusions drawn from observations that had previously been made were verified; an example is the excessive accumulation of free water in the 12 in. depth of entrenched sand under the pavement on Section No. 37. No appreciable accumulation of free water has ever been found on Section No. 36 where the design is the same in all respects except that the sand blanket extends to intersections with the side-slopes. As this sand blanket on the roadway shoulders does not appreciably shrink and crack when it dries out, it also protects the underlying clay soil from excessive loss of its moisture and shrinkage during drouths, hence it retards excessive moisture content fluctuations and volumetric changes in the clay soil-substructure.

Sand for this purpose is not always economically available. On Section 32 the crown of the clay soil-substructure was entirely covered with an asphalt mat 48 ft. in width. The concrete pavement was laid directly on the asphalt mat and the asphalt on the roadway shoulders was covered with native clay soil. It appears that from the viewpoint of maintaining uniform moisture content and volume in the clay soil-substructure, the asphalt mat serves this section practically the same as the sand blanket serves Section No. 36. It has also been observed that the asphalt rises into joints and cracks in the concrete pavement and prevents leakage of rainwater.



Shrinkage Cracks on Shoulders. In Some Cases Cracks in Soil Sub-Structure Were So Deep a Fish Pole Could Be Inserted.

On Section No. 4 the concrete pavement was laid directly on the native clay soil-substructure and the contraction or "dummy" joints were placed 10 ft. apart. This test section has continuously retained a comfortably smooth riding surface with practically no cracks in the concrete. Tests made on this section showed no appreciable leakage of water through the joints to the clay substructure soil.

On Sections Nos. 25 and 26 the clay soil was artificially wetted more than on other sections directly prior to the placing of the concrete pavement. This and other observations made in the state show that the bringing of a clay soil-substructure to its average subsequent moisture content and volume immediately before laying the pavement on it is not a cure-all by any means, but is one of the many items that should be considered in the design of the roadway structure.

Relative to the free water that accumulates in the entrenched sand under the pavement on Section No. 37, it was found during the 1936 observations that after the atmospheric temperature receded several degrees below freezing, the free water elevation gradually receded to below the bottom of the sand and that when the temperature rose, the free water again rose into the sand. During the period from Feb. 6th to Feb. 15th the weather conditions were favorable for checking the relative temperature and water elevation movements because there were cycles of cold and warm weather during that time. The platted curves show the free water elevation fluctuates with the temperatures of the sand. As has also previously been mentioned, it was first thought that the free water in the sand came from fissures in the soil-substructure. No fissures have yet been found. During this 1936 period, free water again rose to the top of pavement on Sections Nos. 13, 14, 23, 24, 25, and 31. As usual, it did not occur on any other test section of the 13½ mile project. Section No. 24 is of the same design as Section No. 37 and Section No. 23 is of practically the same design. It is not known what effect the oiled clay soil under the gravel on Section No. 23 has on this phenomenon. The superstructures of Sections Nos. 14 and 23 are entirely on clay soil fills ranging from 6 in. to 4½ ft. in height. One end of Section No. 13 is in a slight cut at one end and runs to a maximum 2½ ft. fill. A part of each of Sections Nos. 24, 25, and 31 is hill-cut varying from 1.3 ft. to 2 ft. Section No. 37 ranges from 1.8 ft. cut to a 6½ ft. fill; that part where the data on fluctuating freewater were taken is an approximate 2 ft. fill of native clay soil. On Sections Nos. 23, 24, and 37, in particular, it appears that rain or gravity water accumulates in the large voids in the entrenched sand and gravel directly under the pavement. One question is, "Where does the water go when it recedes below the 12 in. of sand on Section No. 37 during cold weather?" Another question is, "Why does the water seep to the pavement surface through contraction joints during warm weather and not run out of an open hand-hole in the pavement at a lower elevation on the hillside?"

Rather than hold these data until a thorough study is made and detailed conclusions included herewith, they are being released at the earliest practical time in order that all who are interested may study it.

As shown by the progressive profiles, the pavement on some test sections has retained a comfortably smooth riding surface, while objectionable irregularities have developed on others. Practically no cracks have developed in the pavement on some sections, while much cracking has occurred on other sections. There is a reason for each and every surface failure.

Fourth Year Data

During the fourth year some of the sections became so rough that they had to be brought to a uniformly smooth riding surface. For this a mud-jack was used in places and bituminous repairs were employed at others.

During the summer of 1937 the entire project was subjected to extended dry weather. On the test sections where the roadway shoulders were built entirely of clay soil, cracks formed in the soil and shrunk appreciably in volume. On Sections No. 6 and 14, the soil on the shoulders receded in places as much as 8 in. below the top of edge of pavement. On the entire project where the soil-substructure was not protected from loss of moisture by roadway shoulder coverings of sand, caliche, gravel, or asphalt mats, the average estimated subsidence of the clay shoulder soil below top of edge of pavement was 4 in to 5 in. In many instances longitudinal cracks developed between the edge of pavement and the clay shoulder soil. In some places it was found that the clay soil under the edges of pavement receded from the bottom of pavement, leaving air spaces between the bottom of pavement and top of soil-substructure.

Resume, Volume IV

Resume, Vol. IV, Oct. 21, 1936, to Oct. 21, 1937.—Shortly after the mud pump work was started, changes were made in both the machinery used and the method of handling it—to such an extent that the type of work performed was improved and the cost per square yard of pavement raised was appreciably decreased. All mud pump work on the project was performed between the dates of October 23, 1936, and April 12, 1937.

Because of the extending of observations on the riding surface of the entire project to October 15, 1937, additional vertical pavement movements were detected at places other than where the mud pump was used, as shown on the "Slab Profile" sheets. On Slab No. 14 a "dummy" joint rose during this period to approximately 0.2 ft. above its original elevation. As it was not desired to alter the design of this test-section, an application of asphalt was placed on each side of the high joint to prevent a traffic hazard. The expansion joint at Station 505+07 also rose appreciably. The 12 in. depth of entrenched sand on this section impounds water on the underlying clay soil. Comparatively little warping of the pavement on Section No. 36 occurred where the 12 in. of sand under the pavement extends to intersections with the roadway side-slopes.

No appreciable additional movements occurred in the pavement on Section No. 32 where the entire crown of the clay soil-substructure was covered with an asphalt mat. As has been stated, the object of this asphalt mat was to test its qualifications for the preventing of excessive wetting of the clay soil substructure during rainy seasons and the preventing of excessive loss of moisture from the soil-substructure during drouths. This information is desired for use in sections of the state where sand or similar non-expansive materials are not economically available.

No appreciable openings of expansion or contraction joints have ever been found on Section No. 4 (10 ft. joint spacing). When the entire research project was gone over in July, 1937, and all open joints and cracks were filled with asphalt, no filling was necessary on Section No. 4. This section has also continuously retained a comfortably smooth riding surface.

It is expected that observations will be made on this research project, from time to time in the future, and that if additional outstanding movements occur in the pavement, detailed data will be taken and reports made thereon.

OBSERVATIONS BY THE WAY

By
A. PUDDLE JUMPER

¶ These Texans are certainly a friendly, cordial, cosmopolitan, neighborly crowd. Even when you criticize them, they smile, shake your hand, and invite you to come and see them again.

• •

¶ Some time when you want to tell an audience that an engineer is a d—— liar, and you want to do it diplomatically, just say: "The engineer spoke with such cocksuredness and verisimilitude that it belied belief." By the time that soaks in the edge will be worn off.

• •

¶ For night driving in Texas through the cities and towns be sure you go equipped with a step ladder and flashlight. If you don't I'm sure you'll not be able to follow the route signs.

• •

¶ Like several other states, Texas has its "Slick When Wet" signs. A mighty weak apology, I say.

• •

¶ Many congratulations are due to some one in Texas for the excellent erosion control efforts so evident along their highways. Ditch checks, drop inlet culverts, terraced right-of-ways and terraced contiguous farm lands, gully dams, shoulder, ditch and backslope sodding, plantings and many other means are serving the state effectively and with pleasing appearance.

• •

¶ Oklahoma, between Tulsa and Oklahoma City, at least, reminds one of Pennsylvania—soil, agriculture, oil wells, crooked roads, etc.

• •

¶ Congratulations to Kansas for that long stretch of stabilized road on U. S. 169 and 65 in Anderson County. I'd rather drive it than nard paving.

¶ April 7th and 8th the maintenance engineer, Dudley Jones, of Oklahoma, was glued to the telephone. One of the heaviest snows they've had for some time descended suddenly and highways in the western part of the state were blocked. All snowplows had been stored so he was busy getting them all organized again to open traffic lanes.

• •

¶ I'll bet many will be as surprised as I was to learn that the lowest spot in a river bed in Oklahoma is over 1,200 ft. elevation. The western part of the state is about 4,000 ft., I'm told. The whole state slopes to the southeast.

• •

¶ As I came through Missouri I noticed they had the maintenance trucks outfitted in one respect like the new maintenance trucks in Illinois. On top of the middle of the cab is a red light showing to the rear. It is connected with a device that flashes the light off and on. A good idea, that, for other states to pick up.

• •

¶ One thing that was hard for me to understand was why U. S. 75 was so crooked about 17 miles north of Tulsa, Oklahoma. With all the wide open prairie around there something should be done about straightening up those myriad sharp curves.

• •

¶ On U. S. 169 in Kansas there is quite a bit of gravel surfacing. Congratulate your maintenance or patrol crews on the condition of that road, Mr. Nuss. Practically every mile of it is very well maintained.

• •

¶ Riddle:

Scramble Ike Ashburn (Texas) with Don Lee and what do you get?

Answer: Datus Proper, the live wire secretary of the Texas Good Roads Association.

¶ Just south of Tulsa on U. S. 66 I noticed tail lights on some of the pony truss spans. It was raining so I never stopped for a picture. The reflector type auto tail light is welded on a bracket on the batter posts of the top cord of the pony truss spans. Novel idea.

• •

¶ You know, I think the American Road Builders' Association should establish a division for state highway department technical personnel only. It might be called the Engineering Division of the A.R.B.A. Standing committees of engineers, only, could produce technical reports that could be established, regionally, as recommended practice. An encyclopedia of highway engineering might easily be the final result of published recommended practice. What do you think about it?

• •

¶ I passed one piece of new road location north and east of Bristow, Oklahoma, on U. S. 66 that sets a record, probably, in curve elimination with economy of construction. The state relocated 2.9 miles, making the road 2.0 miles long, reduced a total of 917 degrees central angle curvature to 21 degrees total; i.e., eliminated 891 degrees' curvature and the cost of grading, including rock, plus 20-ft. 9-6-9 concrete slab will cost only $52,000 in all. I claim that sets a record.

• •

¶ If you don't know this fellow, Moon, chief engineer of Oklahoma State Highway Commission, get acquainted. He is one fine chap.

• •

¶ The roadsides in Kansas look quite ragged and unsightly. Trash is not picked up that lines the ditches, shoulders and backslopes of the right-of-way. Clean 'em up, Nuss, the driving public notices those little things.

¶ Since Julian Montgomery took charge of the state highway engineering I understand he has eliminated about $2,000,000 worth of state day labor work. It is done by contract now.

• •

¶ I also understand that Chief Engineer Montgomery has eliminated the bug bear of the highway contractor, viz., claims for extra work caused by disagreement. I call that signal service.

• •

¶ Following sign is erected on U. S. 66 just northeast out of Oklahoma City, Oklahoma:

CEMETERY
STAY IN LINE

Believe me, I turned around and took another road; I'm not yet ready to take my turn at pushing up daisies.

¶ You will recall that I promised to tell you about a bridge which is expected to be built in this country, the likes of which there is not one in this country at this time. This contemplated crossing is to be a pontoon bridge across Lake Washington east out of the business district of Seattle, Washington. Progress on the proposed pontoon bridge has not yet advanced to a stage where the state highway engineer is in a position to give information on the design of the structure. When it's ready I'll get the dope.

• •

¶ Congratulations, Prof. McNew, on your successful 14th Annual Highway Short Course of Texas A & M College.

• •

¶ Do the highway engineers of Texas have their fun? They love to chide Gibb Gilchrist with his monicer—Dean.

¶ It was certainly a relief to visit the Texas State Highway Commission. All doors to the offices of the department heads were open, except that of the chief engineer. John Q. Public has easy access to department heads. No "pass-words," or detailed report on the reason for your call was asked or expected. That is true public service. Texas is not alone in this. I've visited other states also, that believe in the "open door" policy. Here is what Murray D. Van Wagoner, Director of Highway of Michigan, has to say:

"I am a firm believer in the 'open door" policy with contractors and their association. Our offices are never closed to these men and we are never too busy to sit down with them to discuss mutual problems and iron out any misunderstanding."

• •

¶ Col. Chevalier, past president of the American Road Builders' Association, can draw a crowd to hear him talk, like sugar can draw flies. People flock to him for miles around. I've never known one of them ever to be disappointed. If any man is doing more for highway promotion, I'd like to see the color of his hair.

Congratulations, Colonel. If you were twins the highway industry could use you both just the same.

• •

¶ Every little bit, added to what you've got, makes just a little bit more. I'm glad to add my feeble contribution toward making any highway meeting a success.

• •

¶ Texas has a great amount of fine highway work with wide shoulders, beautified roadsides and well kept right-of-way.

• •

¶ Seems like I've talked a lot about Texas. You'll grant it's justifiable. Texas is a big place.

¶ As I reflect on Texas, I am constrained to inquire into the present condition of Gubernatorial Candidate Thompson.

I wonder if he can demonstrate that there has been any improvement now in the bottom hole pressure that bothered him so long?

What, you ask, does this mean? Ask any Texas highway engineer, I was about to answer; but that would be wrong. It so happened, for some unknown reason, State Highway Engineer Montgomery of Texas called all his district and resident engineers away from the meeting of the Texas A & M Highway Short Course on the afternoon that Col. Thompson was scheduled to explain his bottom hole pressure. So I suggest you get the answer from those county engineers, college professors, or engineers of the U. S. Bureau of Parallel Ruts who were in attendance.

• •

¶ Really, it's not what you might think. It has something to do with pressure at the bottom of an oil well casing and is a first cousin of conservation.

• •

¶ I was deeply impressed with the

neatness of the road sides of Texas highways. I discovered the answer. The crew shown herewith walks both sides of the roadbed and picks up all trash—clear to the right-of-way lines.

¶ Before, during, and after clearing a right-of-way in Wisconsin. No dynamite was used in this job, only a La Plant-Choate trail-builder mounted on a Caterpillar RD-4. After the trees were chopped down, the 57 stumps were removed in 15 minutes. This road building job is on the lands of the Holt Lumber Company.

A new motor vehicle light has been developed which pierces fog sufficiently to enable a driver to proceed through a dense fog at 25 to 40 miles per hour. The light gives clear vision for from 50 to 150 feet in a fog that obscures vision 5 feet ahead of the radiator with ordinary lights.

American Road

WASHINGTON, D. C.

IMPORTANT PROGRAM AT

Down the Road

By CHARLES M. UPHAM

Engineer-Director,
American Road Builders' Association, Washington, D. C.

GRADE CROSSINGS INCREASE GRAVES

Horrible grade-crossing accidents in 1937 added 1,875 graves to the cemeteries throughout the nation. Of this number, 1,607 were the result of automobile-train collisions. The remainder involved pedestrians. What's worse, the carnage hasn't diminished so far in 1938.

Hundreds of newspaper stories concerning grade-crossing accidents come across my desk every week. "Death" inevitably finds its way into the headlines of these stories and the words that follow in the paragraphs below always describe a gory scene. Take this one, for example: "Five Die As Passenger Train Crashes Into Car—One of the worst automobile tragedies ever to happen in this community was that of Monday afternoon when five lives were snuffed out instantly when passenger train No. 18 crashed into an automobile about two miles south of here. The five, all members of one family, except a small baby, a grandson, were crushed to death." Here's another, equally as bad, concerning a truck: "Train Hits Truck, Driver Is Killed—Engulfed in flames, the unidentified driver of a truck was killed here today when it was struck by a northbound express train."

Until recent years the entire burden of grade-crossing elimination rested with the state governments. They had difficulty in financing the elimination of the most dangerous crossings and little progress was made. The federal government has, therefore, found it imperative to assume a large part of the responsibility of grade-crossing elimination, reconstruction and protection. On December 31, 1935, there were 234,231 grade crossings on Class 1 railroads in the United States. During 1935, 2,071 crossings were eliminated and 887 were added, making a net total of 1,184 eliminations. Prior to 1935 the additions of grade crossings always outnumbered the eliminations. Since 1935, the first gains of eliminations over additions have been registered. There are now 230,000 grade crossings throughout the 48 states.

Oklahoma Congressman Wilburn Cartwright has introduced a bill in the current session of the national Congress to continue federal aid for highways through the fiscal years 1940 and 1941. His bill carries an all-important stipulation concerning grade crossings. It sets aside $50,000,000 for the fiscal year 1940 and the same amount for the fiscal year 1941 "for the elimination of hazards to life at railroad grade crossings on the federal-aid highway system and elsewhere, including the separation or protection of grades at crossings, the reconstruction of existing railroad grade-crossing structures and the relocation of highways to eliminate grade crossings and necessary surveys and plans therefor—."

With the number of highway accidents increasing each year and reaching an all-time high of 40,000 in 1937, there can be no more important consideration on the part of Congress at this time than passage of legislation continuing federal aid for building more and better highways. In this added construction there can be no more important activity than the elimination of railroad grade crossings. For, unless the American motoring public obtains increased highway expenditures for the elimination and protection of grade crossings, you may fill a new grave that, figuratively speaking, will be dug by thousands of highway users by the end of this year or next.

VAN WAGONER TO BE INSTALLED AS PRESIDENT

Plans for the activities of the American Road Builders' Association during the next 12 months will be formulated in Washington, D. C., May 11, 12 and 13, when the organization holds its May meeting at the Willard hotel.

Murray D. Van Wagoner

A feature of the three-day program will be the installation of Michigan State Highway Commissioner Murray D. Van Wagoner as president and of the other officers and directors.

WEDNESDAY, May 11: 10:00 a. m.—Golf (all day) Congressional Country Club.

7:30 p. m.—Meeting (dinner) Joint Exhibit Committee. Meeting (dinner) Officers of Affiliated Organizations.

THURSDAY, May 12: 10:00 a. m.—Meeting, ARBA Directors (outgoing and incoming).

11:00 a. m.—Annual Meeting, ARBA.

12:30 p. m.—Joint Meeting (luncheon) ARBA and Manufacturers' Division Boards.

2:30 p. m.—Meeting, Manufacturers' Division, followed by Meeting, Manufacturers' Board.

7:00 p. m.—President's Dinner.

FRIDAY, May 13: 10:00 a. m.—Meeting, County Division and County Board. Meeting, Municipal Division and Municipal Board.

12:30 p. m.—Meeting (luncheon) Chairmen of All Committees.

2:30 p. m.—Meeting, Contractors' Division and Contractors' Board. Meeting, Educational Division and Educational Board. Meeting, Planning Division and Planning Board.

7:00 p. m.—Meeting (dinner) ARBA Board.

Builders' Review

MAY, 1938

Failure to stop is the cause of most motor accidents. A careful analysis shows that out of 96,000 deaths over the past three years, 88 per cent occurred when the cars were going straight ahead. Also, 90 per cent occurred at speeds below 50 miles per hour, 80 per cent were on clear days.

A. R. B. A. MAY MEETING

With Our State Groups

ALABAMA

Charles M. Upham, engineer-director of the American Road Builders' Association; Colonel Willard T. Chevalier, A.R.B.A. president, and Congressman Wilburn Cartwright of Oklahoma, chairman of the Road Committee of the United States House of Representatives, were speakers at the sixth annual meeting of the Alabama Road Builders' Association in Montgomery on March 28.

The convention re-elected Alex Hancock of Mobile to his sixth consecutive term as president. Fred G. Owen of Birmingham was chosen vice-president for the second time and A. G. Underwood of Montgomery was elected to serve his sixth term as secretary-treasurer. Directors chosen at this meeting include A. M. Boone, Birmingham; Charles E. Long, Bessemer; George McCullough, Birmingham; S. E. Gellerstedt, Dothan; C. O. Mitchell, Birmingham; George A. Mattison, Birmingham; Fred Hooper, Jacksonville, Fla.; J. D. Pittman, Birmingham; John Donelson, Birmingham; Fred T. Wiggins, Birmingham; Roy T. Smith, Tallapoosa, Ga., and John Harbert, Birmingham.

COLORADO

A systematic study and analysis of the Workmen's Compensation Law in Colorado is being conducted by a committee of the Colorado Association of Highway Contractors under the chairmanship of Luke E. Smith. Another committee of this organization is working in co-operation with the state highway department and the Bureau of Public Roads to establish a uniform schedule of rental rates and fuel allowance rates for construction equipment used in force-account operations. The association's public relations committee has formulated a safety and job identification sign intended to soften the public aversion to detours. This sign is now on the press and will soon be made available to members for erection on highway projects.

CONNECTICUT

Yale university is going to expand its service to the state of Connecticut in connection with highway safety problems, according to an announcement made by its president, Charles Seymour, at the statewide conference on highway safety at the university on April 4. This conference was a feature of Connecticut's Highway Safety Week, April 2-9.

MASSACHUSETTS

Contracts for improvements of various kinds with a total proposal value of $3,233,000 were awarded by municipal bodies in Massachusetts during late March and early April. The governor of this commonwealth has presented to the legislature a proposal to take $10,000 from the highway fund and gasoline taxes, presumably for general purposes. One of the legislative branches has proposed that this sum be distributed to the cities and towns for local highway purposes and the matter is now under consideration.

TEXAS

Meetings of special interest to road builders in Texas during the past month included that of the Colorado-to-Gulf Highway Association in Vernon, April 11; the 14th Annual Highway Short Course at Texas A. & M. College, April 13, 14 and 15, and the annual meeting of the Texas Good Roads Association in Austin, April 18.

The Texas highway department recently authorized the establishment of a safety department to make a detailed study of state highways in order that traffic hazards might be eliminated. The department is keeping a record of all accidents and each one will be investigated to determine if it might have been caused by road conditions. If so, remedial measures will be recommended.

MICHIGAN

The statewide "get-together" banquet, jointly sponsored by the Michigan Road Builders' Association and the Michigan Good Roads Federation in Grand Rapids on April 28, was attended by more than 1,500 road builders and highway users. Charles M. Upham, Congressman Cartwright of Oklahoma and State Highway Commissioner Murray D. Van Wagoner were among the national and state highway leaders who addressed the gathering.

More than 300 persons attended the banquet which featured the fifth annual meeting of the Upper Peninsula Conference at the Michigan College of Mining and Technology at Houghton, April 1 and 2. A joint meeting of contractors attending this conference with the construction division of the state highway department was held for the purpose of discussing changes in the new specifications.

Congressman Wilburn Cartwright

NEW HAMPSHIRE

Work on the first aerial tramway in the United States on Cannon Mountain near Franconia, N. H., is now being rushed to completion. New Hampshire contractors are also preparing to resume the nine projects which they were forced to suspend last winter and to begin six other projects that have recently been awarded.

DEVELOPMENTS IN HIGHWAY LOCATION SURVEYS

By MITCHEL HALL

Associate Engineer, Division 5, Missouri State Highway Department Jefferson City, Mo.

WE care most to know of those things affecting highway engineering policies of the immediate future. I shall endeavor to outline here what I believe to be some of the latest methods used in highway location surveys, made necessary by the vast changes in traffic needs, together with a better understanding of safety requirements. To properly illustrate a number of reasons for these developments, I deem it necessary to cover a few of the theories and principles practiced by engineers in the early stages of highway work. All illustrations cited here are of surveys actually made, including proposed relocations, or of completed construction.

Contract Surveys

With the coming of the good road era, the highway engineer faced a problem to meet the demands of the public. The people wanted, immediately, all-weather roads, or highways which could be traveled twelve months in the year. The urgent need for design plans prompted the contracting of surveys, and at a price which necessitated rushing these surveys beyond all reason.

The locating engineers and designers of that time worked just as diligently at their tasks as we do at present. Their problem was to survey a line and prepare plans with great speed to provide only for an all-weather road. They did justice to the job, but under different circumstances from those of today. Under those same conditions, we probably would do just what they did. Interest was concentrated primarily on construction and little time could be had for surveys and design of plans.

Surveys and plans originally were contracted in Missouri for $100 per mile. These plans served a purpose, even though woefully wanting in accurate information,

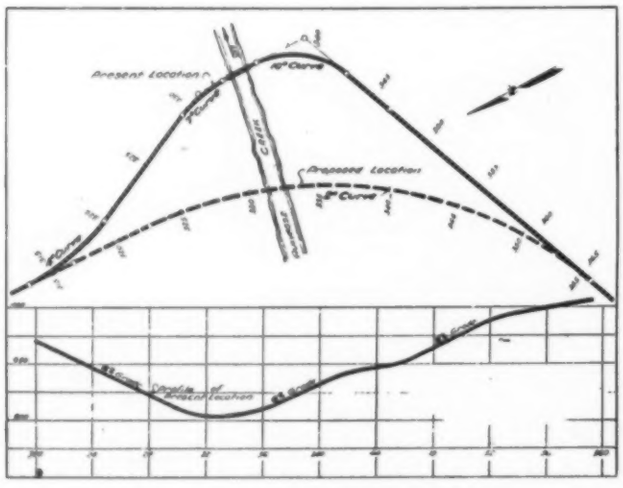


Fig. 1—Proposed Line Improvements.

Fig. 2—Alignment Based on Additional Curvature Controlled by 6 Per Cent Grades. Picture Looking North Along 10 Degree Curve on Present Location Shown by Fig. 1.

but they remained somewhat of a yardstick for determining the amount of work done after the state began making its own surveys.

Limited Surveys

A party was expected to complete 3½ mile or more of surveys per week. Greater mileage sometimes resulted from competition between survey parties. In order to get the required mileage, the chief of party had little time for reconnaissance and none for preliminary surveys. At times he made progress by introducing the old method of running in horizontal curves, which, incidentally, were not so intricate as our present day spirals. The transit party set the PC and PT and maybe an external stake, leaving the rest to be lined in by sight.

In one state the county courts paid for the cost of highway surveys in their respective counties. The funds usually were advanced on a mile basis. A definite sum was allocated, regardless of the terrain. In hilly or mountainous country where much preliminary investigation would be made now, the chief of party was invariably pressed for time. He went ahead setting a line rod as a guide for his party to follow. After the curves were run in, the party chief himself often was not satisfied that portions of the line were properly located; but, finances being limited, he passed up making a change until the entire survey was completed, hoping that he would have time to come back and make corrections. If funds were depleted, the party left for the next job, and the relocation was not made. The result—right-of-way was obtained and the road built on the poorly located line.

6 Per Cent Grades

Right of way was difficult to secure on new locations, so surveys were usually made along existing roads or

Fig. 3—Useless Curves.

property lines on the paths of least resistance. The engineers followed ridges as closely and far as possible until it became necessary to descend on maximum grades into a valley or to cross drainage. The old "Model T" Ford car could climb a 6 per cent grade in high gear, and this was a factor in establishing location. Sufficient curvature was introduced into the line to permit economical construction on that grade. This feature is evident today when it becomes necessary to improve such alignment, which in many cases reverts to the approximate location of the original county road.

The sketch in Fig. 1 clearly indicates alignment based on additional curature controlled by 6 per cent grades. Note the possible relocation. The picture in Fig. 2 was taken looking north along the 10° curve toward the bridge on the present location shown by the sketch in Fig. 1.

Useless Curves

I am told of an incident which probably accounts for at least one of the many and apparently unnecessary curves existing on this state's most traveled highway. A party making one of the first surveys on this future through route encountered a large tree on the centerline. A mattock was the only tool available to chop down the tree. The party chief evidently lacked confidence in the ability of his men to offset a line, for they say he ran in a curve to get around the tree.

A similar incident must have figured in the extra curve shown in Fig. 3, and existing today on this important route. There is no evidence to indicate any reasonable cause for it, and a single 1° curve would be as economical to construct.

Fig. 4—Bridge Built on Curve

Bridges at Right Angles

There was a time when, to the locating engineer at least, it appeared that a highway was a connection between two or more bridges. We have many places where crooked alignment was made in order to build a bridge at right angles to the stream or railroad to avoid additional expense in design and construction. This condition has been responsible for numerous highway accidents. Thanks to the bridge engineers, the practice has been abandoned in most cases and structures are now designed to fit the alignment. Fig. 4 shows one of these bridges located at right angle. Because of the number of fatal accidents occurring from the sharp curve approaching it, this spot has been dubbed locally as "Dead Man's Curve." Note the scars on the guard fence from recent collisions.

A relocation as shown in Fig. 5 has recently been made to correct this condition. This was done by simply introducing a 2° curve which extends across the bridge site and adjacent to the old structure. The department proposes to replace this bridge with a multiple box culvert, thereby permitting full width of roadway including shoulders which further reduces the hazard by giving the driver no sense of restriction.

Fig. 5—Relocation to Correct Condition Shown in Fig. 4.

Out of Date Alignment

The necessity of constructing as quickly as possible, with limited annual revenues, a large mileage of roads probably accounts for a large portion of our out-of-date highway alignment, and who can say that the officials in charge did not act wisely? We have enjoyed the use of them all this time. On the other hand, had the undertaking been established on a more uniform upbuilding of the entire system, even at a heavier initial cost, and sufficient study given to our location on a permanent basis, we would have had less expense for upkeep, greater safety, and would not now be relocating to meet the demands created by the changing character of motor vehicles.

Those roads have served a useful purpose but at the same time they were instrumental in leading us farther in the wrong direction. The alignment was good enough at that time for gravel surfaced highways, but in later years when it became necessary to pave these roads we tried to save as much of the original investment as possible. The outcome was high type pavements on compromised locations. We realize now that if the road

warranted the higher type surface, it also warranted improvement in alignment.

Reference is made to Figs 6, 7 and 8 for practical changes which no doubt should have been made at the time of placing pavement. In each instance, the cost of the increased length of pavement probably would have offset the additional expense for excavation on the better alignment.

Many of these old main highways are obsolete as a result of the characteristics of modern traffic. In most cases the pavements have outworn the alignment. The reason is, obviously, that the principal routes were built first and were laid out and designed by methods hereinbefore described and based on 1920 or 1925 traffic. The speed limit then was from 25 to 35 miles per hour and reckless driving was an exception. In those years the use of sharp degree curvature was common and was even considered acceptable practice in road locations. Not so long ago a 500 ft. radius, or the equivalent of a

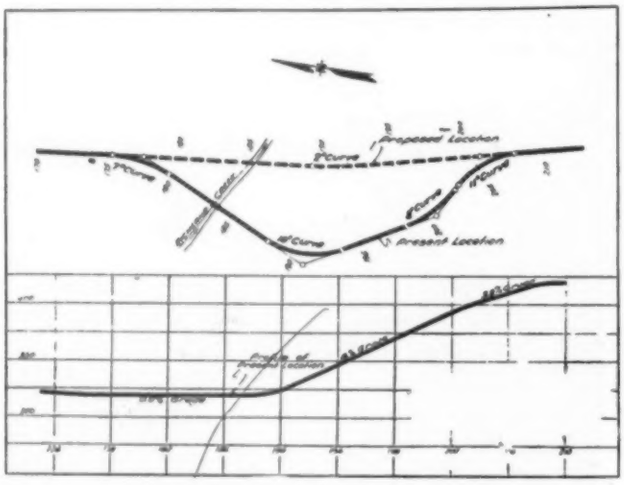


Fig. 6—Proposed Line Improvement.

11° 28′ curve, was minimum for primary highways and a 300 ft. radius, or 19° curve, was satisfactory on secondary roads. But, "Two wrongs don't make a right." Naturally, we believe that the present policy in location work is a step in the right direction.

Public Demands

With the advent of faster traffic, the former alignment standards gradually became out of date. The traveling public demanded roads capable of serving more safely faster vehicles. With the further improvement of motor cars, this demand became more and more insistent.

Speeds are now on an average of 50 to 70 miles per hour and streamlined driving is the order of the day. The trend in all transportation is upward. The number of motor vehicles on the highways has doubled since 1925 and commercial vehicles have increased about five times in number in this time, whereas, highway accidents have continuously climbed to a greater proportion.

This rapid growth on our chief highways led to hastily prepared plans in order to meet new conditions.

Attention is directed to Fig. 9. A study of this project after its construction indicates that a better design might have resulted if the lanes had been separated by sufficient distance to allow a separation of traffic at the wye with a structure which is not now possible with the paralleled lanes only a few feet apart.

Within the last two or three years the trend in roadway design has been toward dual or multiple lane high-

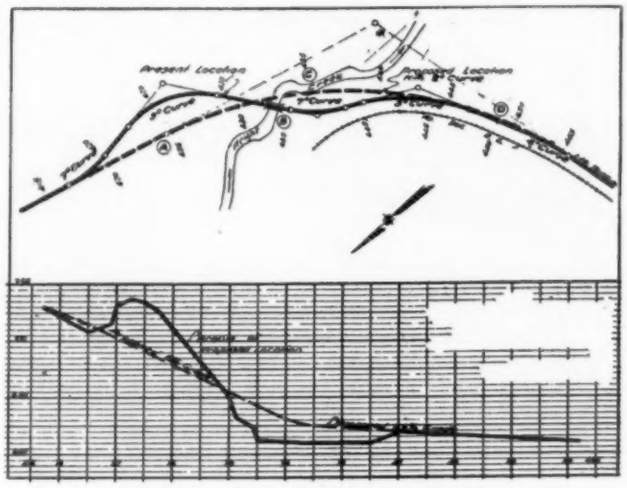


Fig. 7—Proposed Line Improvement.

ways, primarily for safety; however, there is no simple formula for accident prevention or for the location and design of safe highways. For instance, we cannot say that all 10° curves without superelevation are dangerous. Nor can we say that all 2° curves with full superelevation are safe. The speed of the vehicle will make a difference. On the other hand, we can establish definite principles for correction, based on experiences.

Safe Designs

Mr. James S. Bureh, Engineer of Statistics and Planning, North Carolina State Highway Commission, in an article in the November, 1937, issue of "Better Roads" states that the proximate causes for rural motor vehicle accidents in that state are somewhat as follows, expressed as percentages of the total:

Driver faults	72
Highway faults	11
Miscellaneous faults	17

Mr. Burch sets forth two methods of improving the driver situation:

1. Safety education for those who will be reasonable.
2. Enforcement for those who will not be reasonable.

It is enough for our purpose to grant that his conclusion is right and pass on to the cause for highway faults due to poor location.

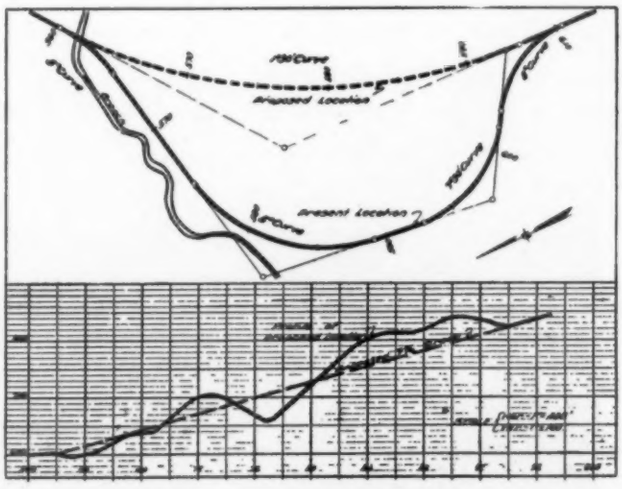


Fig. 8—Proposed Line Improvement.

TABLE I.—CLASSIFICATION OF ROADS

Traffic	Class A 4,000 or More	Class B 750-4,000	Class C 300-750	Class D 200-300	Class E 100-200	Class F 50-100	Class G 50 Max.
Surfaced width	More than 2—10 ft. lanes	2,000 or under, 2—10 ft. lanes; more than 2,000, 2—11 ft. lanes	20 ft. min.	20 ft. min.	9 ft. min.	9 ft. min.	9 ft. min.
Shoulders or roadbed width	8 ft. min. clear. Surfaced or unsurfaced shoulders	Same as Class A	6 ft. min. clear. Surfaced or unsurfaced shoulders	28 ft. roadbed	28 ft. roadbed	24 ft. min.	20 ft. min.
Alignment between control points	2° 30 ft. max.	4° max.	5° max.	8° max.	10° max.	20° max.	28° max.
Sight Distance 5 ft. height	4 lanes—800 ft. 4 lanes divided—500 ft. 3 lanes—1,200 ft.	Same as Class A for more than 2,500 vehicles. Less than 2,500 vehicles, 1,000 ft. desirable—500 ft. min.	600 ft. min. except in difficult topography. 400 ft. absolute min.	400 ft. min.	350 ft. min.	250 ft. min.	150 ft. min. Widen at apex of vert. curve
Grades	5% max. where more than 15% of traffic is commercial; otherwise 6% max.	5% max. where feasible. 8% permissible in rough topography	6% max. where feasible. 8% permissible	9% max.	10% max.	10% max.	12% max.
Right of Way	125 ft. min. for ultimate 4-lane traffic	100 ft. min.	100 ft. min.	80 ft. min.	80 ft. min.	66 ft. min.	60 ft. min.
Structures over 20 ft. clear span	4 ft. wider than ultimate pavement	Same as Class A	24 ft. min.	24 ft. min.	24 ft. min.	20 ft. min.	18 ft. min.
Structures less than 20 ft. clear span	Full width of roadway	Same as Class A	Same as Class A	Same as Class A	Same as Class A	Same as Class A	Same as Class A
Railroad grade crossings	Eliminated if practicable, otherwise protected with automatic or manual device	Same as Class A	Same as Class A	Same as Class A	Protected Automatic Signal	Reflectorized	Same as Class F
Surface Types	Pavement	Pavement	Dustless all-weather surface	Dustless All-weather	All-weather	All-weather	All-weather

Highway faults may be listed in the following order:

Narrow bridges
Poor location
Narrow pavements
Improper superelevation
Rough shoulders
Inadequate warning signs for construction and maintenance operations.

Narrow bridges and poor locations account for about 50 per cent of these conditions. Under the item of poor location, we should include unsuspected sharp curves and restricted vision. The most dangerous points are those where danger is not expected by the driver. Railroad grade crossings cannot be charged to poor location but to a lack of finances. However, the grade crossing accidents are the most positive type of fatal accidents.

It is my opinion that unless highway accidents reduce considerably automobile manufacturers will be forced by law or public opinion to design their equipment for lower speeds. If this is not the case, should we begin now to design our important interstate highways for even higher speeds?

The time possibly is not far distant when we shall mark all our roads for "Design Safe Speeds." We now are locating and designing to permit reasonably safe operation on our main routes at speeds of 60 and 70 miles per hour. This of course is not economical or practical on our less important farm-to-market roads, which should be marked for speeds for which they were designed and built.

Reduced Curvature

One important factor in the solution of the highway fault problem is the reduction of curvature to a practical minimum and increasing sight distances.

The American Association of State Highway Officials recently adopted the recommendations as set forth in Table I as a guide to uniformity along this line.

From this chart it may be noted that very sharp curves are being avoided on the higher class roads even at the expense of large additional construction costs. Where absolutely necessary to use sharp curves, they are being spiralled as well as superelevated and widened in accordance with modern methods.

You might ask how these latest standards are determined. To answer this question, I shall make reference here to the relation of speed to highway design as discussed in a booklet issued April 30, 1937, by the Division of Design, Bureau of Public Roads.

"Drivers do not adjust their speed to the importance of the road but to the character of the terrain and to the physical characteristics and limitations in the design of the highway, such as curvature, superelevation, pavement widening, grades, and sight distances."

Safe Speed on Curves

Design speeds considered to give greater safety are arrived at as follows:

The skid factor for ice is approximately 0.104 ft. per foot or about 1¼ in. per foot and therefore should be the limiting superelevation slope, except in sections not subject to freezing where the slope might be increased to 1½ in. per foot provided a non-skid surface is used.

A large number of driving tests, as covered by an analysis in the proceedings of the November, 1936, annual meeting of the Highway Research Board, indicate that the maximum safe side-friction factor is 0.16 for vehicles at a speed of 30 to 60 miles per hour, 0.15 for 65 m.p.h. and 0.14 for 70 m.p.h.

The centrifugal force of a vehicle traveling around a curve of constant radius at a uniform speed is defined by the relation (Formula 1) $P = \frac{Wv^2}{gR}$ in which P represents the centrifugal force, W the weight of the car, v the velocity in feet per second, g the acceleration of gravity in feet per second, and R the radius of the curve in feet. Changing v in feet per second to V in miles per hour and substituting 32.16 for g there results:

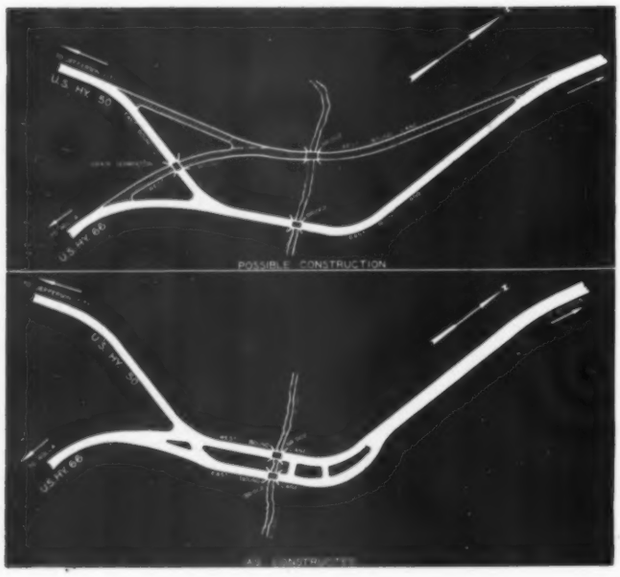


Fig. 9.

$$P = \frac{.067\ W\ V^2}{R} \quad \text{or} \quad \frac{P}{W} = \frac{.067V^2}{R}$$

The term $\frac{P}{W}$ may be referred to as the centrifugal ratio which must be counterbalanced by the superelevation slope S and the friction factor F. Thus the Bureau arrives at the following for safe speed on curves.

$$\frac{P}{W} = S + F = \frac{.067\ V^2}{R}$$

Maximum Curvature for Various Design Speeds

Using maximum superelevation and safe side friction previously discussed here S + F equals .264 for speeds up to 60 miles per hour, and .244 for 70 miles, equaling $\frac{.067\ V^2}{R}$. The safe minimum radius, therefore, is (Formula 2) .0264 V^2 or .244 V^2.

Superelevation

We have previously mentioned a maximum superelevation of 0.104 ft. per foot, that is 1¼ in. per foot or the skid factor for ice. However, superelevation must be limited for practical reasons. A car traveling around a curve at low speed where excessive superelevation is used tends to slide down since the slope is greater than the centrifugal ratio.

The Bureau of Public Roads suggests a 75 per cent or three-quarters proportion as being desirable. For example, curves designed for 60 miles per hour would be superelevated to compensate for the centrifugal force of a car traveling at 45 m.p.h.

Widening Pavements on Curves

Pavement widening has little relation with this article, except that it is a consideration in determining curvature in close places. Extra width of pavement is provided on curves because a vehicle or train of vehicles occupies extra width and as it is difficult to keep vehicles to the center of the occupied lane. In the bulletin on "Transition Curves for Highway Alignment" previously referred to, the Bureau suggests for the purpose of widening driving lanes 10 ft. in width, and multiples thereof, the following (Formula 3)

$$W = n\ [R - \sqrt{R^2 - 400}] + \frac{V}{\sqrt{R}}$$

in which "n" represents the number of lanes and "V" the speed in miles per hour, 400 being the square of 20′, the average length of wheel base of freight trucks.

Present practice for the degree of curvature below which no widening is required varies between 5° and 8°. The Bureau suggests that no pavement requiring less than 2 ft. of widening in accordance with the above formula be widened. This results in widening no two lane pavements on curves flatter than 4° for 70 m.p.h., 5° for 60 m.p.h., 6° for 50 m.p.h., 7° for 40 m.p.h. and 8° for 30 m.p.h.

In Missouri we use maximum widening in accordance with the above formula on curves 6° and over for the entire length of the circular curve. Widening is invariably placed entirely on the inside, with straight transitions through the spirals and proportioned to the distances.

Spiral Transitions

Spiral transitions for horizontal curves similar to those universally adopted for railroads are gradually being introduced in highway work for greater safety.

At moderate speeds the average driver can, in effect, make his own transition into a curve within the limits of the lane occupied by the vehicle, but with increased speeds he must cut corners and create a hazard by temporarily crowding into the rightful path of another. The spiral is intended to not only make it possible for the driver to confine his car to his side of the road on a curve, but encourage him to do so.

Both spiral and superelevation transitions should be long enough so that the speed for which the curve is designed is such that most drivers will have sufficient time to change their car from a straight to a circular motion and thereby "swing" into the circular curve in his own lane.

The required length of transition as suggested by the Bureau may be determined as follows: (Formula 4)

$$L_s = 1.58 \frac{V^3}{R}$$

in which L_s represents length of spiral, V the velocity of car or constant speed in feet per second, and R the radius of the curve.

Fig. 10—Long Tangent Approaching Railroad Overhead.

This McDonald Experience Proves INTERNATIONAL Efficiency

ABOVE: *This gives an idea of the soft ground over which the six International TD-40 Diesel TracTracTors travel most of the time on this job. Two of the units are shown here working with a scraper and a bulldozer.* **AT RIGHT:** *Another Model TD-40 TracTracTor and scraper moving between 55 and 60 cubic yards an hour.*

• Six International TD-40 Diesel TracTracTors are doing a large share of the excavating for the William P. McDonald Construction Company of Flushing, N. Y., on 4½ miles of new highway near the eastern end of Long Island. Four of these Internationals are operating 4½-yard, 4-wheel scrapers on this job. The other two, one equipped with a bulldozer and the other with a bullgrader, are on grading work.

It was originally planned to let tractors and scrapers open up the work and then turn over the main excavation to other equipment. In a thorough five-day test, however, two International TD-40 Diesel TracTracTors proved so efficient on scraper work that the other four were purchased and the major part of the dirt moving given to them.

The facts and figures gathered by this nationally known construction company prove the value of International Diesel TracTracTors on the job. Our nearby International industrial power dealer or Company-owned branch can give you additional information on this model, and on other crawler and wheel tractors, and power units in the International line.

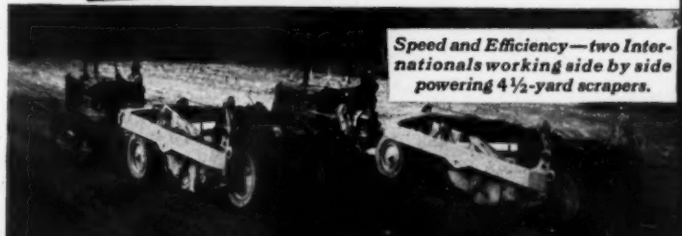
INTERNATIONAL HARVESTER COMPANY
(INCORPORATED)
180 North Michigan Avenue Chicago, Illinois

Five-Day Test on Internationals Your Guide to Efficient Power

★ One International Diesel TracTracTor moved 1,951½ cubic yards in 34.75 hours, averaging 56.2 yards per hour on an average haul of 524 feet. Average load was 4.11 yards and an average of 13.65 trips were made an hour.

★ The second unit, identical with the first, moved 2,061½ cubic yards in 34.25 hours, averaging 60.3 yards per hour on an average haul of 514 feet. Average load was 4.25 yards and an average of 14.15 trips were made an hour.

★ Their flexibility and travel speeds on scraper work, their correct balance and absence of unnecessary weight, the remarkable performance of the Diesel engine, and a minimum of "time-out" for maintenance won this job for TracTracTors.



Speed and Efficiency—two Internationals working side by side powering 4½-yard scrapers.

INTERNATIONAL Industrial Power

Fig. 11—Spirals Used for Reduction of Curvature in Close Place.

Spiral transitions also may be used to advantage in improving existing sharp curves at hazards where physical obstructions will not permit flattening the circular curve.

The Locating Engineer

Adequate tables concerning the various methods recommended for design at safe speeds have been compiled, but established regularious and principles are not all there is to the proper locations of highways. The engineer uses these as his standard, but he must be able to apply them in a manner that suits best the locality traversed. The good locating man must be capable of visualizing lines and grades as they will appear after construction in relation to the topography. If he is able to pick and keep in mind on reconnaissance work the approximate final location, considerable savings in cost of surveys and construction may be effected through rough country where it often becomes necessary to do much preliminary surveying.

Survey Methods

Modern surveys are usually made, based first upon a reconnaissance and information available from strip maps or the valuable U. S. topographic sheets. If the topography is exceedingly rough and there are two or more possibilities, contours are taken and a trial line projected in the office. On the actual field survey this projected line is then shifted slightly to fit the ground and obtain the most desirable and economical location.

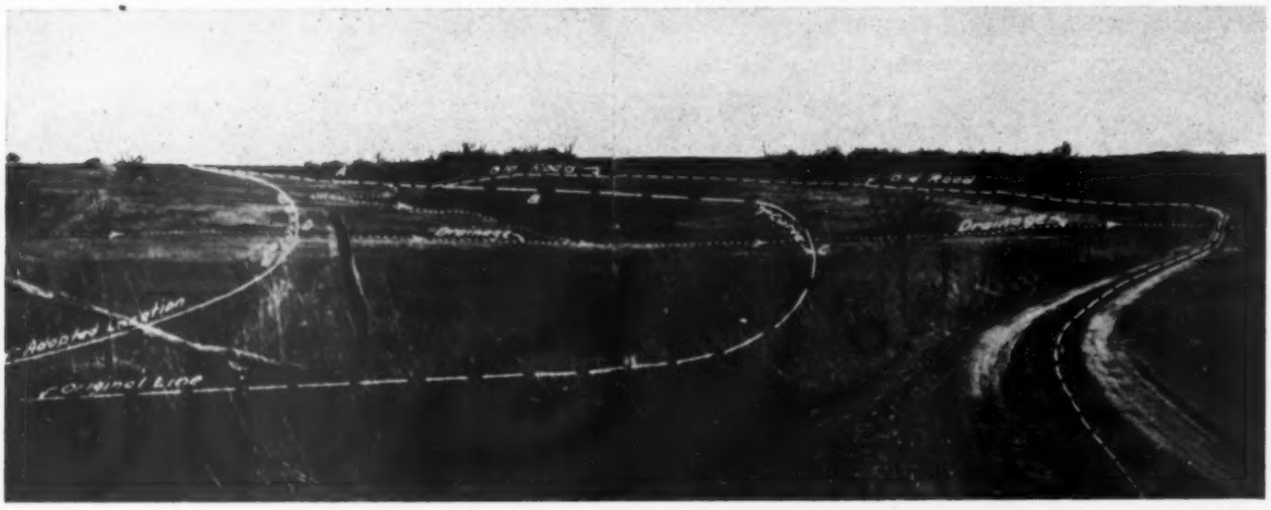


Fig. 13—Old Road and Original Line and Adopted Location for a Supplementary Route.

Figures 10, 11 and 12 produce an example of this condition. An existing overhead structure consisting of eight 40 ft. deck girders and one 75 ft. steel truss center span—all set on three tower and two concrete end bents supported by piling—is in good repair and represents an original investment too large to abandon the structure. However, the number of accidents occurring at this bridge make it imperative that something be done to better the conditions. An 80 ft. bluff at Point A in Figure 12 was a control point. The concrete approach spans on the north end could be altered economically by widening transition varying from 0 at the steel center span to 3.5 ft. at the beginning of the bridge, or a distance of 60 ft.

Believing that the real cause of the accidents was the circular curves approaching the bridge from tangents two miles in length, as well as the 1° 48 ft. curve practically compounded into the sharp 20° 39 ft. curve, spiral transitions were used and the centerline shifted to give the effect of single 8° curves spiralled. While this is not exactly a satisfactory solution, we think it the best to be had and utilize the present investment.

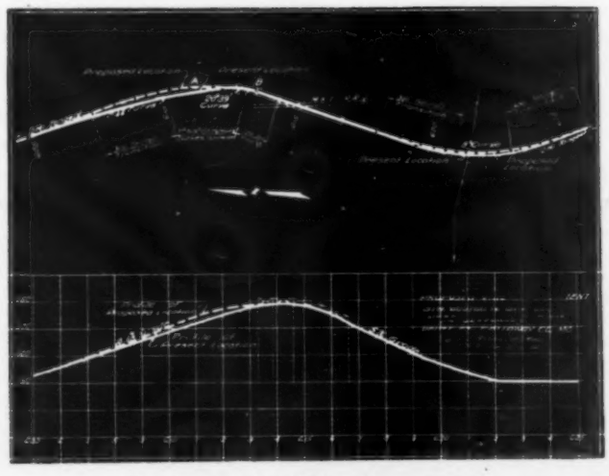


Fig. 12—Proposed Line Improvement.

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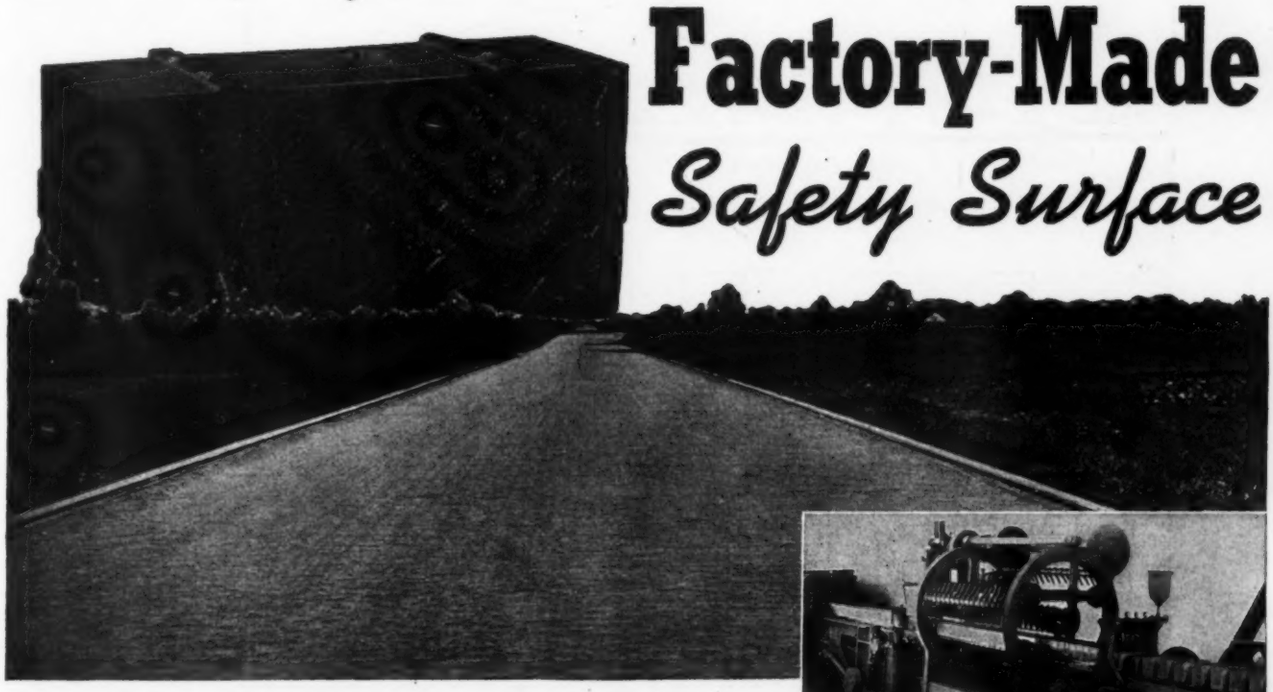

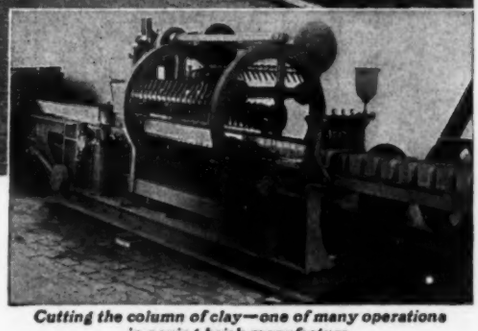

Cutting the column of clay—one of many operations in paving brick manufacture

SAFE..LESS COST PER YEAR OF SERVICE..COMFORTABLE

You know in advance of its construction that a brick pavement will have the highest non-skid rating.

For brick is the only pavement with a factory-made surface. Each unit is cut to a uniform coefficient of traction by automatic machines operating under constant conditions. Each brick may be inspected before it goes into the pavement. The variables and personal equation hazards of on-the-job manufacture are eliminated. Just before filler is applied, the brick are sprayed with a separating agent which permits excess filler to be completely removed. The full non-skid properties produced by wire-cutting are 100% efficient from the start.

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ADDED SAFETY FEATURES: A brick pavement is amply visible at night and restful and non-glaring by day. According to Highway Research Abstracts, in experimenting with artifical colors for other pavement types brick red has been found "most satisfactory and attractive." Traffic lanes and other safety markings are made permanent in the pavement by use of contrasting colors of brick.

BRICK

FOR NEW AND RESURFACING JOBS

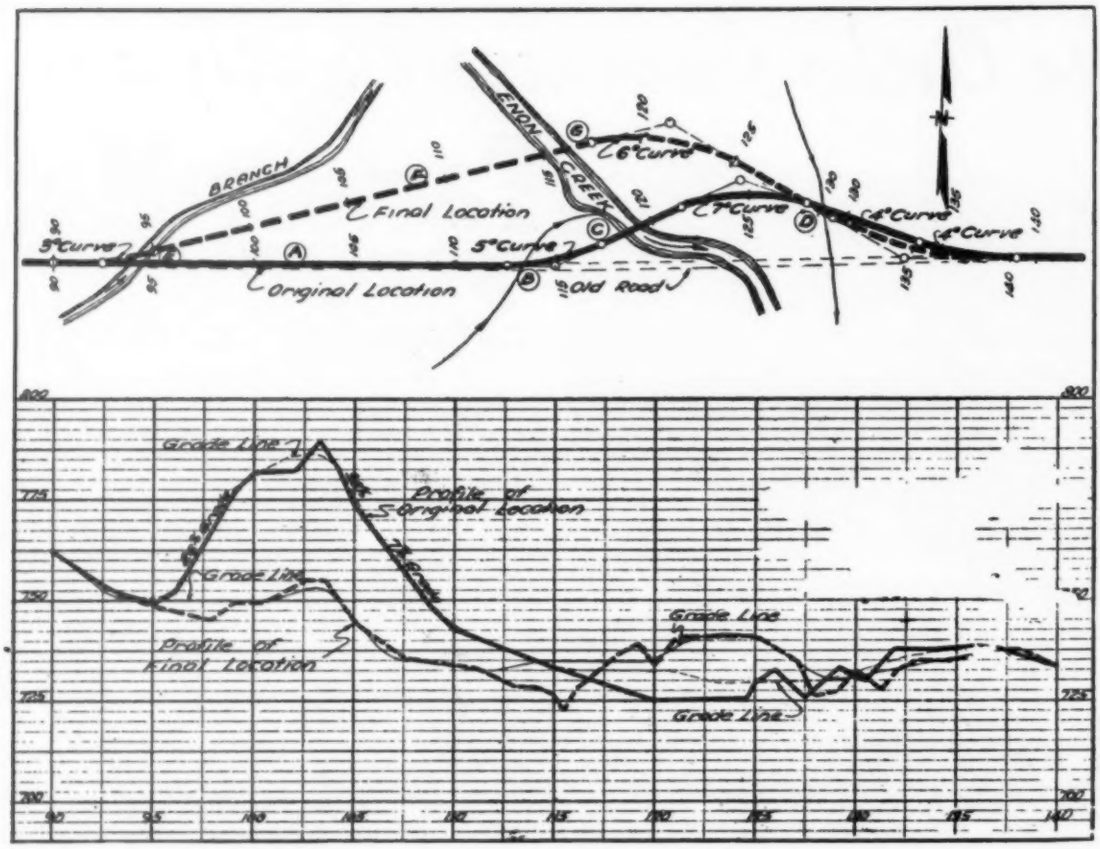

Fig. 14—*Locations for a Proposed Farm-to-Market Road.*

There are many factors involved on a survey which can only be brought out after a thorough investigation. I believe there are many worth mentioning here. With this in mind, I have included some pictures, plats, and profiles of actual conditions which best illustrate my points.

Necessary Curves

Exceptional cases may justify deliberate attempts to build into the highway a series of curves gradually decreasing radii to encourage the driver to slow down before reaching a section of highway which must be traveled at a lower speed to be safe. Such changes should be made as gradually as possible and advantage should be taken of every change in topography to reduce any appearance of forced alignment.

Figure 10 is a good illustration of a condition where additional curves undoubtedly should have been introduced. Two miles or more of practically straight alignment connect at either end with the sharp curves on the approaches to this bridge. One might say that the driver is invited to drive 70 or 75 miles per hour on these straight stretches of highway, only to be confronted suddenly with this hazard which has been responsible for several serious accidents.

Horizontal and Vertical Curve Combinations

In general, locating engineers and designers should avoid combinations of horizontal and vertical curvature which in effect deny the traveler an opportunity to pass. It invites the careless driver to stray from his traffic lane into the path of another.

Compound curves should be avoided if possible. Where necessary to use them, they should be held as nearly to the same degree as practicable; otherwise, the average driver gets the "feel" of a curve and if it is compounded into a much sharper curve he might find his car in the opposite lane or in a ditch.

Sight Distances

Sight distance assumes great importance in highway safety. No properly designed highway should have sight distance less than safe stopping distance at any point, and, if topographic conditions are favorable, a safe passing sight distance should be provided so that overtaken vehicles may be passed with safety. In most cases, minimum vertical sight distances are designed now in accordance with Table I for classification of roads. The Federal Bureau seldom approves plans for any road of a type lower than Class E, which requires 350 ft. or more vertical sight distance.

The maximum curvature recommended in the same table will provide the minimum horizontal sight distance. When conditions necessitate exceeding the curvature shown, care should be taken that the benching in cuts or flattening of back slopes required to obtain the sight distance is not excessive, otherwise, reducing the horizontal curvature is preferable.

Short Curves

Curves of short length on small central angles should be avoided. Even when properly transitioned they leave the appearance of a short bend. The Bureau recommends that for a central angle of 5°, the curve should be at least 500 ft. long, and for each decrease of 1° in the central angle, the curve be lengthened at least 100 ft.

Channel Changes

Channel changes are often economical means of attaining good alignment. On roads of high types, if difficult terrain, it is sometimes cheaper to construct channel changes than to build bridges. Channel changes

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should not be used indiscriminately, however. Preservation of landscape values should be an important principle in any highway design. It is recognized so far as appearance is concerned that seldom can man-made water courses improve on nature, but careful planning can minimize this feature.*

Supplementary Roads

Standards and construction practices advanced as the years passed and the through routes were completed. The engineers thought they were getting somewhere. About this time, however, public sentiment demanded supplementary or farm-to-market feeder roads which, of course, should be built at low construction costs based upon services rendered. Whereupon, we automatically reverted to the original methods of cheap location surveys, making the same mistakes of poor alignment, narrow rights-of-way and other items affecting design. I believe we are gradually working away from them again.

While I do not advocate expensive or high type supplementary roads, I think we need just as much intelligent foresight in planning these surveys in order to obtain the best to be had at the least construction cost. Due consideration and investigation often results in improved alignment and grades at even less expense.

In Fig. 13 it is apparent that the original survey for a supplementary road using a 7° curve was made with the idea of a minimum right-of-way damage to this field. From the design and construction standpoint, however, a 4 by 2½ box culvert would be required at Point A, excavation would be in solid rock through the cut, necessitating reversed grade lines at Point B, and an 8 by 4 box culvert would have been necessary at Point C. By simply specifying a 4 by 6 cattle pass structure at Point D to appease the property owner, in lieu of a 4 by 4 box normally required, the adopted 4° curve location eliminated the additional crossing of drainage and avoided the steep grades through rock excavation, actually reducing construction costs with little or no extra damage to the pastured land. The reduced curvature was especially desirable in this instance as there is a one mile tangent on one end of the curve and at least four miles straight alignment through prairie country on the other end.

On another survey for a proposed farm-to-market road the original location, as shown in Fig. 14, followed the old road except for crossing of the creek where overflow conditions practically eliminated the advisability of building a bridge at the site of the old ford. Further study of this line revealed ledge rock at the surface in the hill at Point A, a 4 by 4 culvert required at Point B, and a bridge 120 ft. in length necessary at Point C where the stream bed is now washing badly and banks overflowing into the bottom to the east. The final location avoids the steep rocky hill, crosses the creek at Point G at approximately the same skew but at a more desirable bridge location, reducing the length of the structure and keeping the road out of the overflow land between Points C and D. This location is estimated to cost $2,400 less to construct than on the original surveyed line. However, the new location did divide a cultivated field from Points F to G, the right-of-way cost amounting to $500, which reduced the total savings over the old line to approximately $1,900.

Figure 15 represents still another instance of due consideration and investigation resulting in improved alignment and grades at less cost even though on a low class supplementary road. Note the two profiles. Total estimated cost of constructing on the new or final loca-

*(Public Roads, Nov., 1937.)

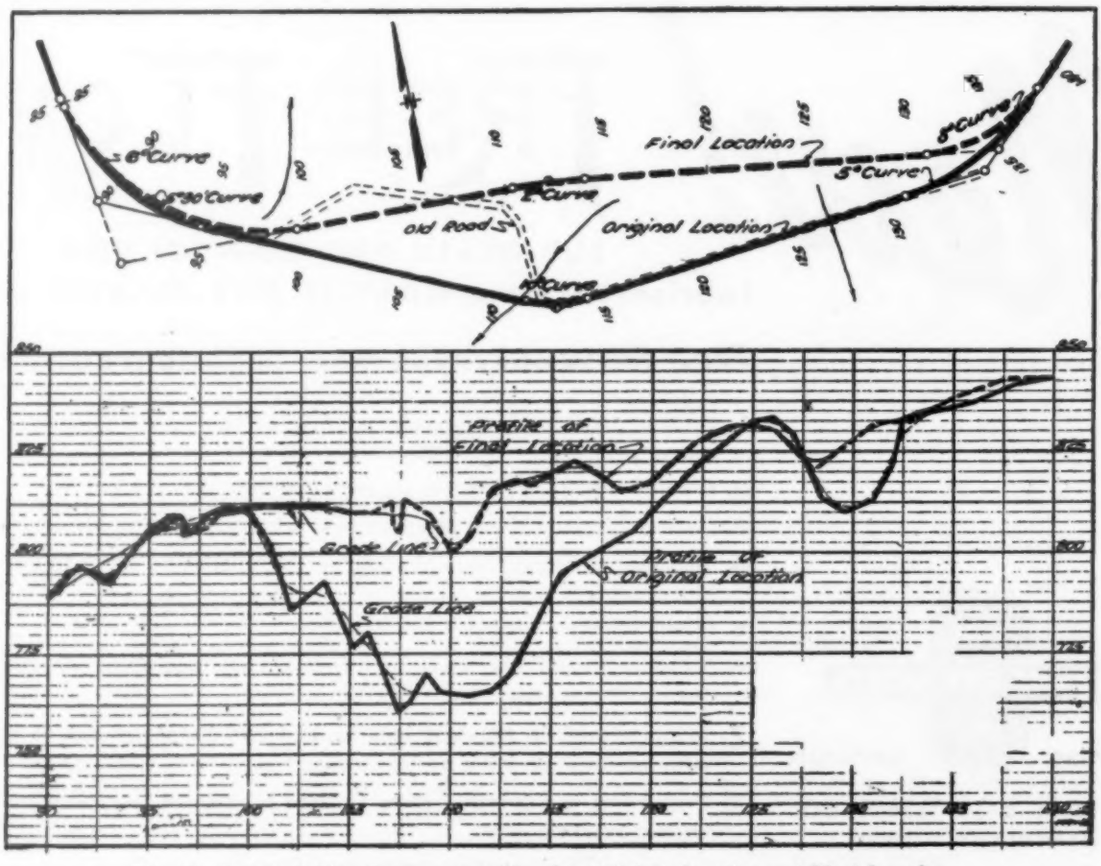
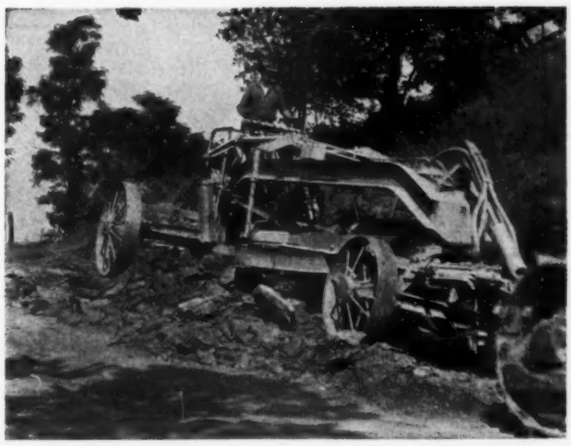


Fig. 15—Proposed Line Improvement Showing Original Location and Final Location.

"CAN THEY TAKE IT?"



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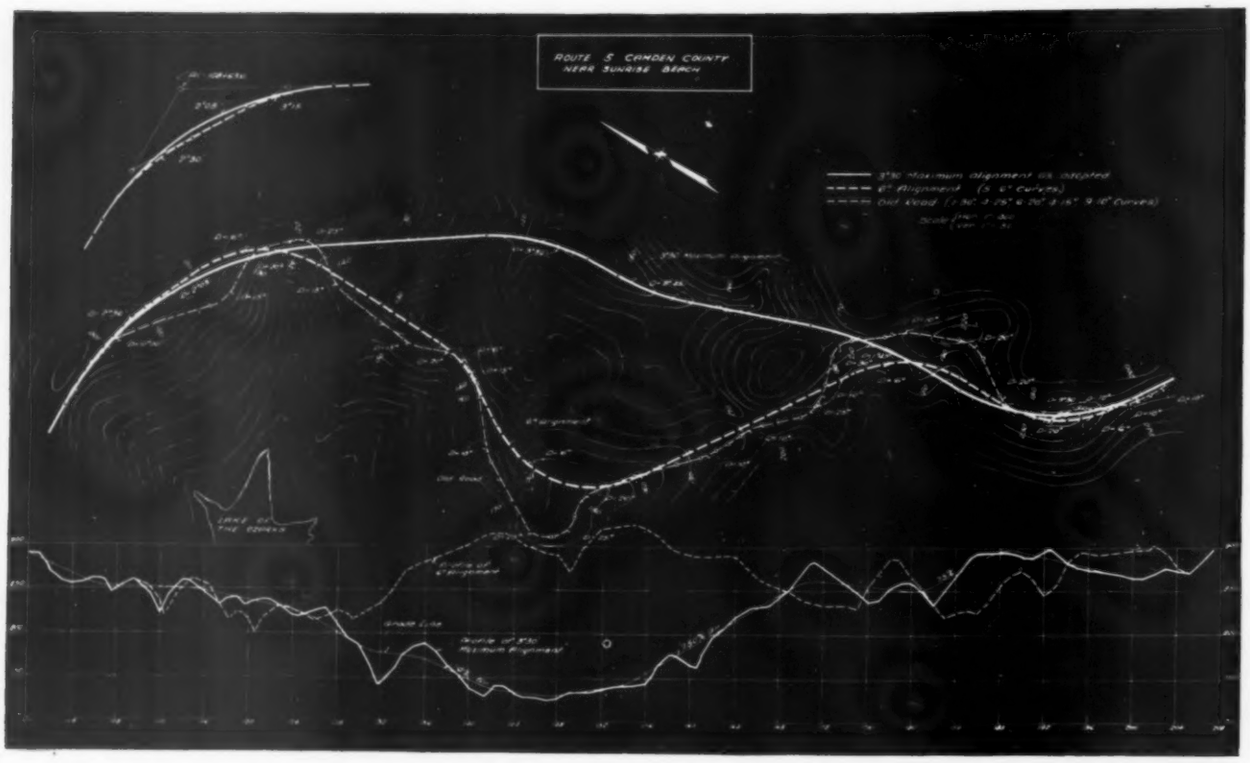


Fig. 16—Survey for Intermediate Type Road Showing Old Road, the 6 Degree Alignment and Alignment as Adopted.

tion amounted to $1,625 against $2,275 on the original location. The right-of-way was given for the original line and a settlement made, without resorting to condemnation, on the relocation for $150, or an actual saving of some $500 using the relocation.

Intermediate Highways

As a fair example of a modern location survey on an intermediate type road, I would cite Fig. 16. This survey meets the requirements for a Class B Highway as outlined in the classification of roads previously discussed. It is applicable to the old saying that one cannot fit 6° curvature on a 10° ridge. Because of the difficult topography along a ridge between two arms of the Lake of the Ozarks, the reconnaissance for this location specified a series of 6° maximum curvature, which, if constructed, meant alignment for a Class C or D road. The maximum curvature recommended in the chart for a Class B road is 4°. Little difficulty was encountered in staying within this limit for the first two miles, as the ridge lies in a general southern direction. On the next two miles, however, the line of the ridge is very broken; in fact, there are 24 curves ranging from 10° to 30° on the present road. The topography is such that once the survey leaves the top of this serpentine ridge any reduction in curvature less than the natural meander of the ridge makes little difference in cost consideration. Construction would be about the same for 6° or even sharper curves so long as the centerline drops into the deep draws, as indicated by Points A, B and C in Fig. 17.

One possibility of an entire new location apparently had not been given much consideration because of a deep hollow just beyond Point D in the picture, but after encountering the difficulty on the 6° ridge line, we

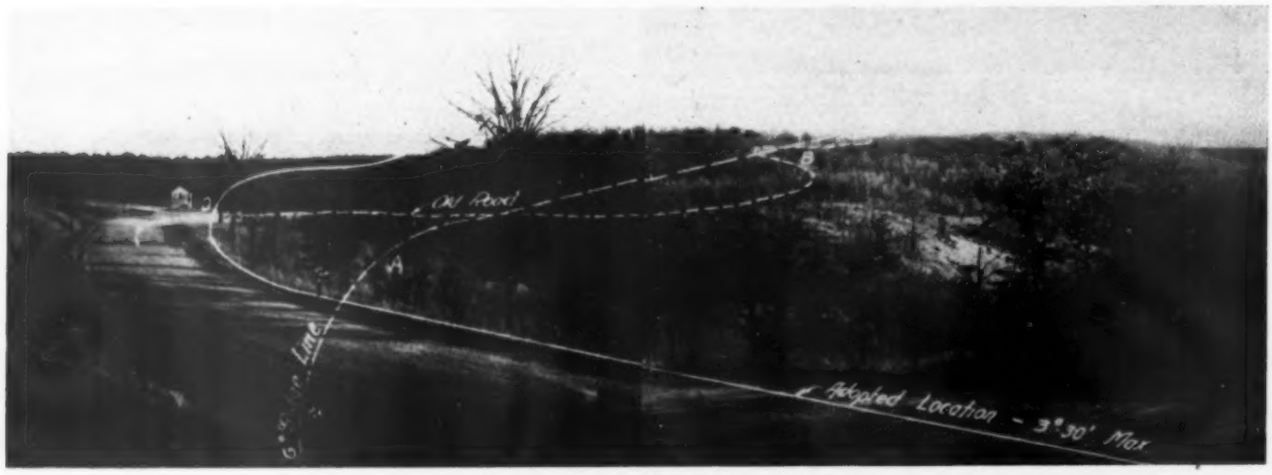
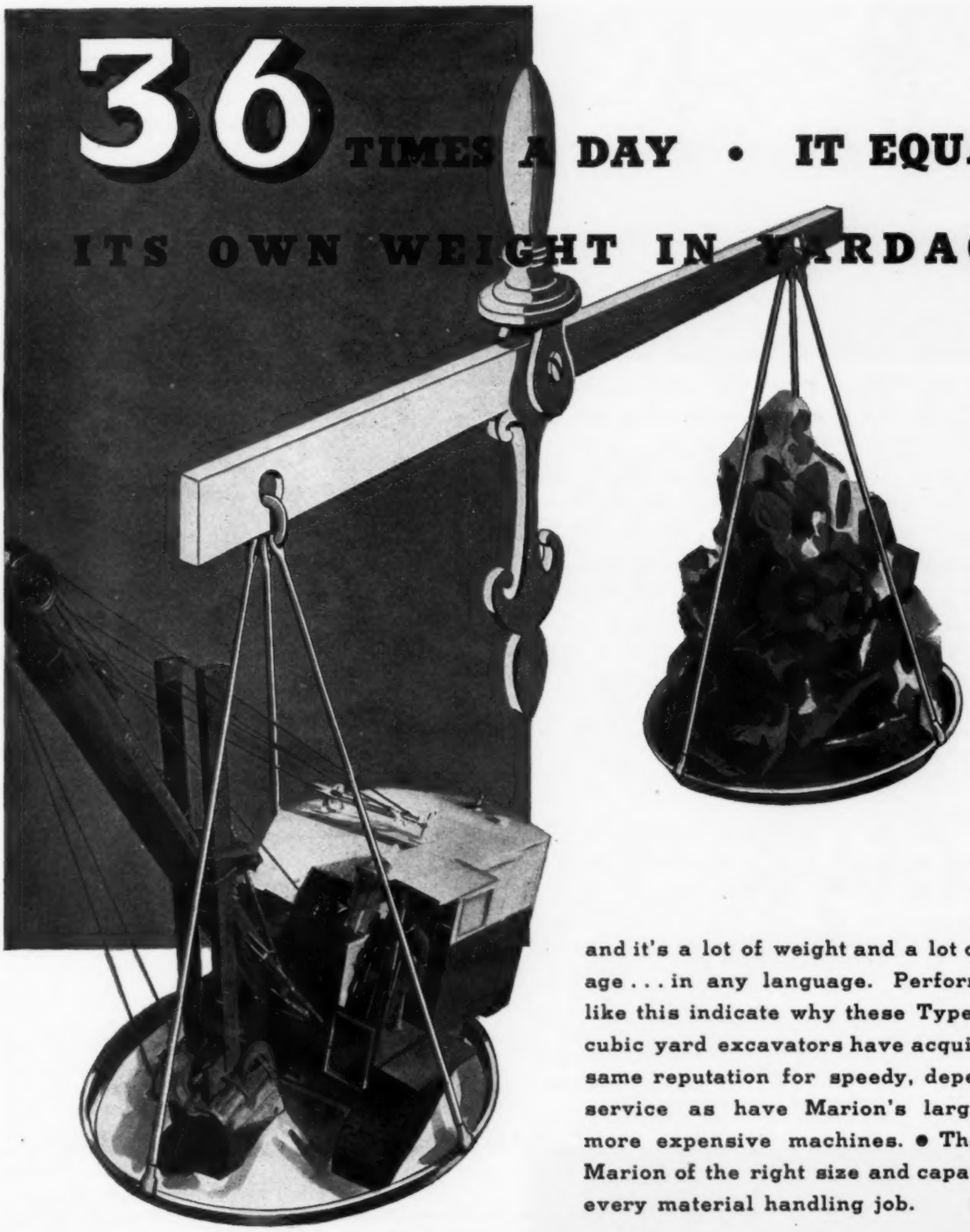


Fig. 17—View on Location Shown in Fig. 16.

36 TIMES A DAY • IT EQUALS ITS OWN WEIGHT IN YARDAGE!



and it's a lot of weight and a lot of yardage . . . in any language. Performances like this indicate why these Type 331-¾ cubic yard excavators have acquired the same reputation for speedy, dependable service as have Marion's larger and more expensive machines. • There's a Marion of the right size and capacity for every material handling job. • •

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Fig. 18—Scene at Sta. 95 + 50 in Survey Shown in Fig. 16.

decided to do more preliminary survey work with the idea of developing this possibility.

Base lines were run, contours taken and all control points noted. These were plotted in the office, a trial line projected and with slight shifting in the field we got a maximum 3° 30 ft. alignment. This line was approximately ¼ mile shorter in length and estimated to be cheaper to build than the 6° ridge line originally recommended. We felt the additional cost of survey was well worth while.

Another consideration on this survey to which I refer is the long 2° 30 ft. curve at Station 108+. A 2° 30 ft. and one 3° 15 ft. curve might have been constructed instead of the flat curve with approximately 600 ft. of tangent distance between curves at considerable savings in cost, as two draws would have been avoided. To do this, however, would have resulted in what some engineers term compound or broken back curves. What tangent distance between curves is necessary to avoid the appearance of broken back curves? I believe this depends somewhat on the ultimate type of surfacing to be applied. If concrete pavement is used, possibly 600 ft. might not be sufficient tangent distance.

The scene shown in Fig. 18 was taken at Sta. 95+50 on the last referred to survey and represents another throught in the location of highways. This line was purposely shifted to this side of the ridge, and without any sacrifice in cost or alignment, to provide for the construction of a scenic look-out.

Primary Highways

The ultimate cost for all types of roads should be compared with the estimated traffic, present investment and detour inconvenience to the traveling public.

The survey for a primary highway as shown by Fig. 19 is an example of where present investment and inconvenience to traffic is a major consideration to offset comparative construction costs. The traffic count on the present road to the Lake area during the summer season exceeds 5,000 daily. The surface is good but the alignment is obsolete for a road of this importance but would be of service as a supplementary road. Often it is less expensive to entirely relocate a road rather than follow the older main highways along a ridge. This was not true in this case. 2° 30 ft. is the maximum curvature permissible for Class A roads in accordance with the present classification. Although plenty expensive and on curves for a greater portion of the distance, a maximum 1° 30 ft. curve line could be obtained along the present road on the ridge. But this would have meant detouring this heavy traffic for at least a year—the present investment would have been destroyed and very heavy right-of-way damages involved, not to mention the ill will of the property owners effected who will still receive the benefit of the present road which will be maintained as a farm-to-market road. Relocating this highway, however, involved much preliminary investigation, because of the limitations for a road of this type and the rough country involved. An idea of the territory might be had by reference to Fig. 20.

Fig. 19—Survey for a Primary Highway.

Fig. 20—New Location of Class A Road (See Fig. 19) Through Difficult Topography.

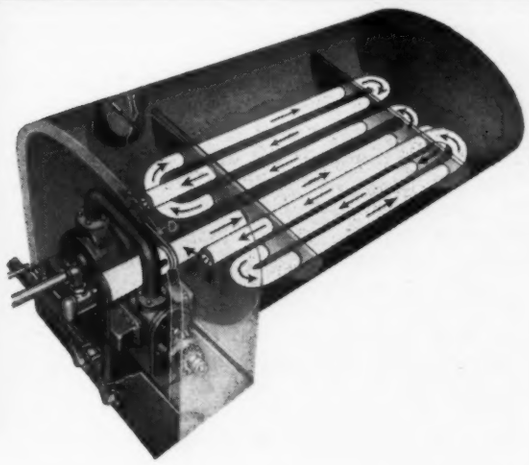
Conclusion

I trust that by these various illustrations I have not given the impression that all of our locations have been at fault. On the contrary, the majority of them have been of the highest types, and stand as monuments to those making them.

The following conclusions appear to be warranted, based upon data and observations set forth in this report.

1. That there is much science involved in the modern layout which was given little or no consideration in former times.
2. That the design engineer is expected to provide various plans for highways, two of which are outstanding at this time. One being for the high type road carrying fast and extremely heavy traffic—the other the local road where maximum economy in construction must be practiced.
3. That heavily traveled roads must be designed for safety even at the expense of large additional construction costs.
4. That the services of the good locating engineer is indispensable for proper locations and in savings effected in the cost of both surveys and construction.

MORE HEAT LESS FUEL



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5. That time and money spent on design and surveys usually pays dividends in the way of better accomplishments.

6. That the science involved in modern designs amplifies the importance of technical and experienced designers in highway work.

7. That the ultimate cost of all types of roads must be based upon the estimated traffic and service rendered, present investments and detours, or inconvenience to the traveling public during construction.

8. That we are faced with rebuilding some of our main highways to suit the conditions that have developed, or of eliminating the traffic hazards from our important routes built originally as all-weather roads only.

Further reference is made to the foregoing illustrations, especially to Figs. 1 and 2. With full knowledge of the highway faults such as portrayed in these pictures, shall we continue to let the unsuspecting driver choose between the alternative of crashing into the dangerous bridge ends or take chances of going over the hill into the creek? The design engineer of today is aware of these death traps and knows that the solution lies in the relocation and improvements proposed, but his problem now is the lack of money to do it. Will finances be made available to correct these conditions?

9. And, finally, that we now have sufficient information available to enable us to determine in advance the cost to a reasonable degree for the majority of all our roads.

With these data at hand we hope to perfect in so far as practicable future surveys for safe highways strictly from an engineering principle and not on a basis of so many miles of surveys per week—the faults of which are now shown by accidents and fatalities.

A glance over the shoulder is not nearly so satisfying as a glimpse of what lies ahead. Time might prove that we are only in the experimental stage in the matter of methods and designs for roads and that the best and ultimate design is perhaps ahead of our present standards.

Acknowledgment—he foregoing is an address presented Feb. 16 at the annual meeting of the Highway Engineers' Association of Missouri.

▼

Fill Construction on Wyoming Highway

The following notes are taken from a paper presented by J. R. Phillips, Casper, Wyo., District Engineer, Wyoming State Highway Department, at the 1938 Highway Conference at the University of Colorado.

High Short Fills—For many years we have found it difficult to obtain proper compaction in high, short fills. These fills are usually in deep draws with a bottom length of 10 to 30 ft. and a top length of 75 to 150 ft. and a height of 40 to 100 ft. The grade line usually changes from cut to fill about two-thirds of the way up from the bottom of the draw and since the sides of the draws are steep, it is difficult to get equipment in and out of the draw. A fill over 60 ft. high has a width perpendicular to the centerline in excess of 200 ft. Our usual practice is to bulldoze fill material into the gulch from above and to use small carry-all scrapers to spread it in layers. The fill is rolled at right-angles to centerline until a height is reached which will allow parallel working. Fills up to 100 ft. in height which were placed by this method two years ago show no appreciable vertical settlement; however, there is a tendency for the upper part of 1½:1 clay fills to sink and to push out the lower part of the fill thereby causing maintenance in refilling to the proper width. This action is probably due to combined shrinkage and side-displacement. Wind and water usually erode high fills badly. We expect to remedy this situation by building terraced fills having slopes that fall outside of the usual 1½:1 slope lines. It costs less to terrace than to flatten these slopes. In fact, any slope from 2:1 to 4:1 on a high fill is both difficult and expensive because it cannot be built entirely with ordinary equipment.

Plating—On several 25 to 30-ft. fills for overhead approaches which were constructed of sand-silt mixtures and on other projects in the blow sand region, it has been found necessary to plate fill slopes with clay to reduce wind erosion. Plating is no problem on shallow fills, but is both difficult and expensive on high fills. On shallow fills a thickness of 3 to 6 in. seems to protect the fills indefinitely, but on high fills a thickness of less than three or four feet cannot be economically placed and rolled. Long hauls may make the cost of plating on large fills prohibitive.

Asphalt-Gravel Curbs and Gutters—During the past construction season, some experiments were made in leading surface water off high fills with an asphalt-gravel curb and gutter. A curb 6 in. high with a 30-in. gutter can be built of crushed gravel and asphalt for about 15 ct. per lineal foot. If crushed limestone is used, the cost will vary from 20 to 25 ct. per lineal foot. Drops are usually made of corrugated metal pipe either whole circle or split in half. Spillways are located at the lower ends of fills and are surfaced with premixed asphalt-gravel material or slab rocks. The latter are unsatisfactory unless they are grouted. The premixed asphalt-gravel curbs and gutters with necessary drops seem to carry the water off quite satisfactorily and do not offer any particular construction difficulties. There is some question as to whether they can be maintained during and after snow storms and how they will affect the operation of snow removal equipment.

Side Hill Fills—The treatment of high side hill fills depends on the material involved. In general, the original ground line is terraced under the proposed fill with a bull-dozer, trail-builder, or perhaps a common road plow. Rock and boulders may have to be hand placed at the bottom edges to start the fill because if a shovel is used, it has to make its first lift on the top edge of the slope, and usually the problem is to get the shovel through on the first cut rather than to build up a fill and still not waste too much yardage. Cuts containing more or less well-graded sand and gravel are often encountered. Even though it involves handling the material twice, every effort is made to place this material where it will be most effective. If there is no binding material in the sand or gravel, a mixture of all the material in the cut with rolling and watering will usually effect the proper compaction.

▼

GRADUATE FELLOWSHIPS IN TRAFFIC CONTROL—The Bureau for Street Traffic Research of Yale University is offering 15 graduate fellowships in the field of street and highway traffic control, each in the amount of $1,400. These fellowships may be applied for by persons having an engineering degree representing four years' work in an accredited college or university. Applicants must not be more than thirty nor less than twenty-three years of age at the time of application. Applications must be upon forms obtained from Mr. Maxwell Halsey, Associate Director of the Bureau for Street Traffic Research, 315 Strathcona Hall, Yale University, New Haven, Conn., and must be returned on or before June 1, 1938.

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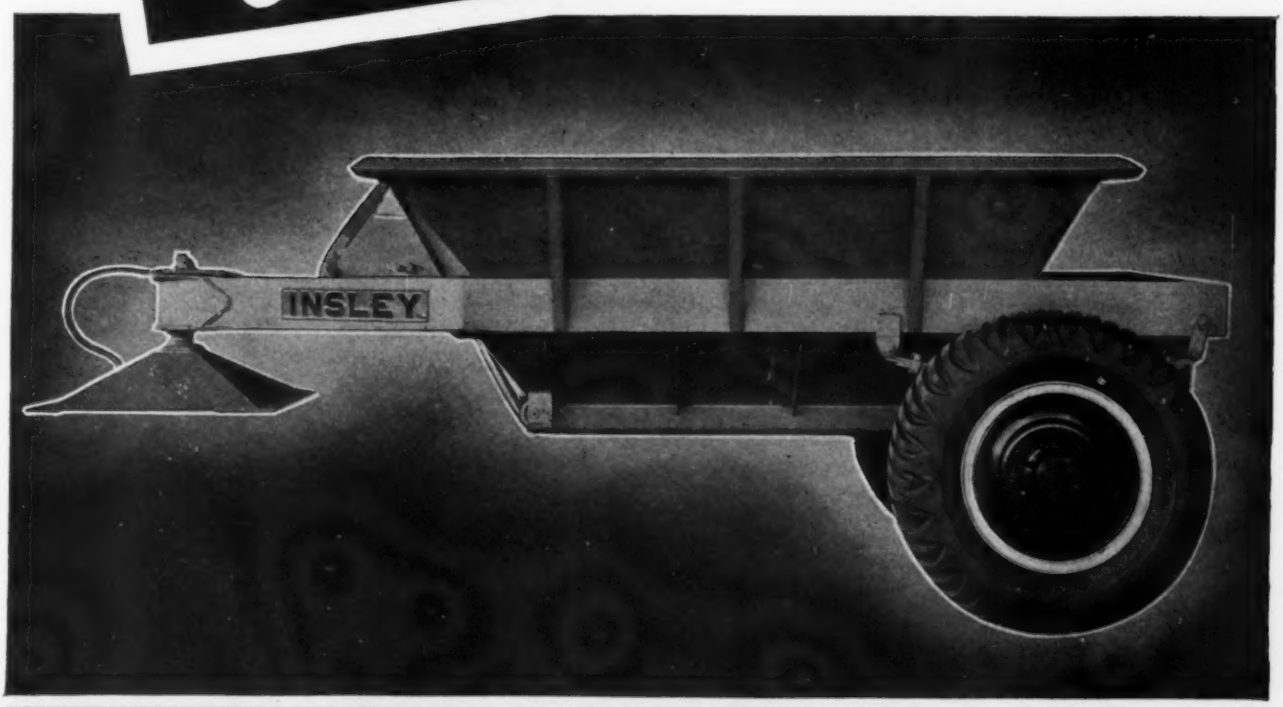


INSLEY

A RATING TABLE FOR SUPERHIGHWAYS

By LORAN D. GAYTON
City Engineer, Chicago, Ill.

ON Feb. 21, 1936, Oscar E. Hewitt, Commissioner of Public Works of the city of Chicago, appointed a committee to study a plan for a superhighway development in Congress St., the plan having been previously submitted to him by Robert Kingery, who was then director of the Department of Public Works and Buildings of the State of Illinois. This plan was developed by D. E. DeLeuw, Assistant Chief Highway Engineer, under the direction of Ernst Lieberman, Chief Engineer of the Division of Highways, State of Illinois, and in general followed plans that had previously been made public by Bennett, Parsons and Frost, and Mr. I. F. Stern.

The committee appointed by Commissioner Hewitt, which was later to be become known as the "Committee on West Side Superhighways," was made up as follows: Loran D. Gayton, City Engineer, Department of Public Works; Wm. R. Matthews, Ass't. Engineer in Charge, Department of Public Works; A. J. Schafmayer, Engineer, Board of Local Improvements; Leslie J. Sorenson, Engineer of Traffic, Department of Streets and Electricity; James J. Versluis, Engineer of Construction, Department of Public Works; Hugh E. Young, Chief Engineer, Chicago Plan Commission.

In his letter appointing the committee, and accompanying the plan, Commissioner Hewitt states as follows: ". . . I desire a report from a group of competent engineers who are also familiar with government requirements and restrictions as to the DeLeuw plan, so that I and others may be advised that the plan is, or is not, the best to meet the needs of a West Side major highway, or in what particulars, and in what manner the plan should be modified."

During the last decade many proposals for a West Side major highway have been submitted and, therefore, in order to arrive at a decision as to whether the Congress St. plan as submitted by the State Highway Department was the best, it was of course necessary that the committee study and analyze any and all of those proposals.

Before selecting the various West Side major highway projects to be studied it was necessary that the Committee determine the boundaries of the area to be considered. The central business district, including the south central, and the north central, is usually understood to mean the area from Roosevelt Road to Chicago Ave. The committee, therefore decided to fix the limits of the traffic district to be studied as from Roosevelt Road on the south, to Chicago Ave. on the north, and extending from Lake Michigan on the east to the Western city limits in Austin Ave. The size and importance of this district is indicated by its population of over 418,000 people (census of 1930), which is one-eighth of the population of the entire city of Chicago.

The Superhighway Projects Studied

Every superhighway project proposed within the last decade, and within these limits, was investigated. The proposals investigated were for highways in locations spread from Illinois St. on the north, to Polk St. on the south. It is to be expected that a highway in Illinois St. would serve some area to the north of it, and a highway in Polk St. would serve some area to the south of it.

The following projects were studied:

Plan No. 1—Illinois-Hubbard-Ferdinand Elevated Highway, submitted by the Chicago Plan Commission.

Plan No. 2—Hubbard-Kinzie Elevated highway, submitted by the Chicago Plan Commission.

Plan No. 3—Illinois-Hubbard-Kinzie Elevated Highway, submitted by John Ickes.

Plan No. 4—Fulton St. Elevated Highway, submitted by John W. Ruzicka.

Plan No. 5—Randolph St. Elevated Highway, submitted by Committee on Traffic and Public Safety, Ald. John A. Massen, Chairman.

Plan No. 6—Madison St., 120 ft. highway at grade, submitted by Chicago Plan Commission.

Plan No. 7—Monroe St. 120 ft. highway at grade, submitted by Chicago Plan Commission.

Plan No. 8—Monroe St. Elevated Highway, submitted by Chicago Plan Commission.

Plan No. 9—Monroe-Adams, Depressed Highway, submitted by Joshua D'Esposito.

Plan No. 10—Congress St. 146 ft. Highway at grade, submitted by Bennett, Parsons & Frost, and I. F. Stern.

Plan No. 11—Congress St. 120 ft. elevated highway, submitted by Chicago Plan Commission.

Plan No. 12—Congress St. The so-called State Plan, submitted by Charles DeLeuw for the Highway Department of the State of Illinois after the plan of Bennett, Parsons & Frost.

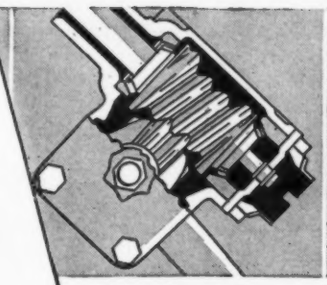
Plan No. 13—Polk St. Elevated Highway, submitted by Chicago Plan Commission.

Plan No. 14—Madison St. Depressed Highway, submitted by Committee on Traffic and Public Safety, John A. Massen, Chairman.

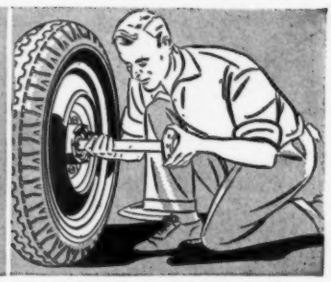
The foregoing tabulation indicates that some of the projects were elevated highways, some were depressed highways, some were developments at grade, and others were a combination of all three. In order to compare an eight-lane highway with a four-lane highway, an elevated with a depressed highway, or a highway costing $11,000,000 with one costing $50,000,000, it became necessary to develop some system of grading that would give rational values to the various items entering into the design and construction of superhighways.

To make a comprehensive study of all of the 14 proposed improvements it was determined by the committee that every value of an ideal highway should be established, and that each value be given an exact numerical rating. The Committee set up a definite method to apply the numerical ratings. This involved the designation of the factors having a bearing on the merit of a plan, the assignment of a weight to each factor in proportion to its relative importance, and the application of each of the factors to each of the plans. A numerical value was determined for each factor as applied to each plan. The sums of the several factor ratings for each of the plans gives the relative value of each of the proposed im-

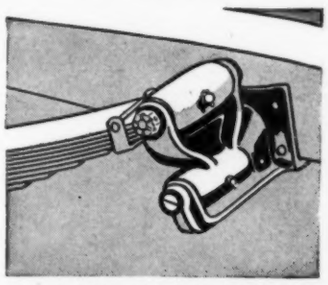
A FORD TRUCK IS GREATER THAN THE SUM OF ITS PARTS



For easier driving and parking—worm and roller type steering.

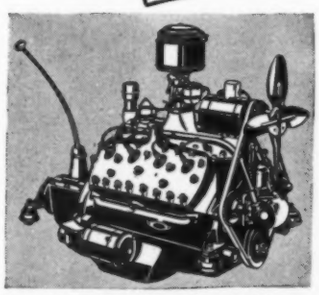


Full-floating rear axle relieves the axle shafts of supporting the weight of chassis and body.



Rear springs are free-shackled at both ends. An earmark of top-quality truck construction.

—BUT LOOK AT SOME OF ITS PARTS!

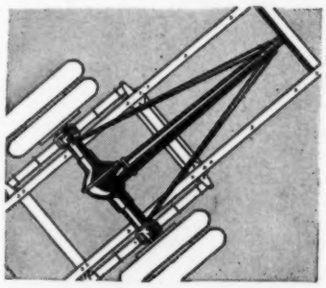


V-type 8-cylinder engine—still rolling up records for performance and economy.

Some truck buyers like to go over a unit part by part, and judge it on "points." A few of the features of the 1938 Ford V-8 Truck are shown here. Some are interesting because they are new improvements. Some are time-proved features which continue to be newsworthy because they represent the type of expensive design and construction which Ford is able to offer at low cost.

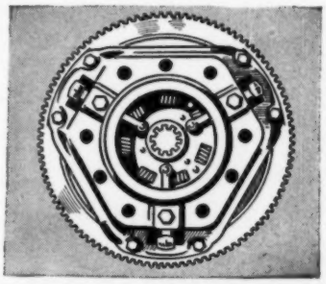
But—a Ford Truck is *greater* than the sum of all its parts. *Into* each truck goes the experience gained in 21 years of truck-building leadership. *Back* of each truck is the constant Ford ideal—to build strong, *lightweight* trucks that put MORE PAY IN EVERY PAYLOAD. And *with* each truck go the time-and-money-saving advantages of the Ford Engine and Parts Exchange Plan.

You get value *far beyond* its price when you get a Ford V-8.



Full torque-tube drive relieves springs of driving and braking stresses.

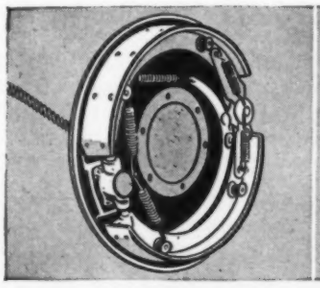
New welded all-steel cab gives extra strength, safety, comfort. 3 inches more head room.



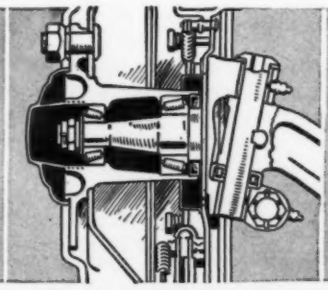
Centri-force Clutch. One of the most efficient, most reliable truck clutches ever built.

FORD V·8

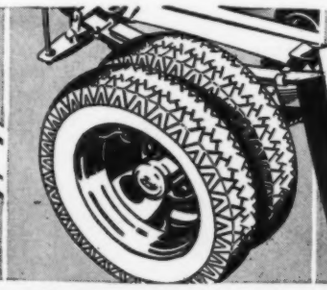
TRUCKS AND COMMERCIAL CARS



New bigger brakes—less pedal pressure—safety of steel from pedal to wheel.



Larger spindles equipped with larger spindle bolts increase the safety factor.



7.50-20 dual tire and wheel equipment is now available at slight extra cost.

ARRANGE FOR AN "ON-THE-JOB" TEST

provements on the basis of the Committee's ratings. The values are referred to hereafter as factors, and the divisions of such factors as sub-factors.

Rating Plan Developed

The Committee set up seven main factors to determine its choice of the recommended plans. These factors, and the weights assigned to them to evaluate their relative importance are:

MAIN FACTORS CONSIDERED AS DETERMINING THE VALUE OF A PLAN

	Weight
1. Measure of safety provided	30
2. Capacity provided	18
3. Location of the improvement	18
4. Feasibility of financing the improvement	13
5. Relative cost (cost per lane provided)	9
6. Aesthetic value of the improvement	9
7. Adaptability of the improvement to stage construction	3
Total Points	100

The time allotted to me will not permit of a discussion of all the above mentioned factors, and the relative weights, but let us consider a few of the principal ones.

The Safety Factor

First let us take the safety factor. The weight assigned (30 out of 100) is an indication of the Committee's opinion of its importance. If location and capacity were the only primary factors, existing streets on the west side could be improved to meet the requirements of traffic at relatively small expense. The demand, however, is for capacity with safety, and safety coupled with speed. Happily, the features of design of a highway that make for safety are the same features that permit of rapid express movements. The safety factor has been provided into two main sub-factors, and these will be discussed separately.

The factor of safety resulting from design or type, with a weight of 20 out of the 30 points assigned to safety was divided into 7 sub-factors, each of which indicates a division of the traffic accidents that occur on the ordinary city streets. The sub-weights assigned are the percentages of accidents in these classifications compared to the total number of accidents on such streets. These sub-weights are based on a study of police reports of accidents in the city of Chicago.

Safety as to Design—The safety factor is given a total of 30 points, and this is divided into "Safety as to Design" with a weight of 20 points, and "Safety as to Traffic Affected," which is given a weight of 10 points.

"Safety as to Design" has been divided into 7 sub-factors as follows:

Intersectional friction
Pedestrian hazards at intersections
Pedestrian hazards between intersections
Street car and track hazards
Medial friction
Marginal friction
Internal friction

Safety regards proportion of traffic affected is the safety factor weight A-9, times capacity factor weight B-14.

These sub-factors are largely self-explanatory. Intersectional friction (vehicular) refers to accidents caused by cross collision of vehicles at street intersections. These accidents may be avoided by separation of grades. Medial friction refers to head-on collisions along the center line of a highway, which may be eliminated by the longitudinal division of the roadways. Marginal friction refers to the accidents along the edges of a roadway, due to cars entering and leaving the parking places, to collision with curbs, and fixed objects within them. These accidents may be reduced by the elimination of parking, by providing sufficient clearances, and by other means. Internal friction refers to accidents within a traffic stream moving in one direction, usually side-swiping due to weaving and speeding. It can be limited by sufficient lane widths and road capacity, but it cannot be eliminated entirely unless we can limit the operation of automobiles to those individuals of 100 per cent intelligence.

It will be noted that the safety rating depends largely on the type of highway proposed in the several plans. Plans numbered 6, 7, and 10 are for highways at grade. This type is given a low rating, as the possible provisions for safety are limited to a traffic signal control at intersections, safety islands for pedestrians, longitudinal separation of roads and the elimination of commercial vehicles.

The type (used in Plans 1, 2, 3, 4, 5, 9, and 14) that has been designated as a "limited way" takes the highest rating, as all hazards are removed except internal friction and some friction along the margins. There is, however, a hazard at the ramps of the elevated and depressed roads due to vehicles entering and leaving the express levels and from entering and leaving the ramps at street intersections.

The elevated highways that provide access to abutting property (Plans No. 8, 11, and 13) do not wholly remove pedestrian hazards, nor the hazards due to parking and unloading. Their safety rating is therefore lower than the "limited way" but much higher than the highway at grade.

Plan No. 12 (the State plan for Congress St.) is for a highway partly elevated, partly depressed, and partly at grade. Its safety rating is proportioned to the ratings of the several parts.

Safety as to Traffic Affected—The factor of safety resulting from the proportion of traffic in the area benefited by the proposed improvement is given a weight of ten of the 30 points assigned to the total factor of safety. This factor, with a weight of ten of the 30 points to safety, recognized the proposition that a highway of safe design but sufficient for but, say one-half of the traffic to be provided for, offers a smaller measure of safety than will a highway of equally safe design that is sufficient to carry all of the traffic. The ratings for this factor are the products of the ratings for safety of design and the proportion of traffic provided for, compared to the estimated required volume.

The Capacity Factor

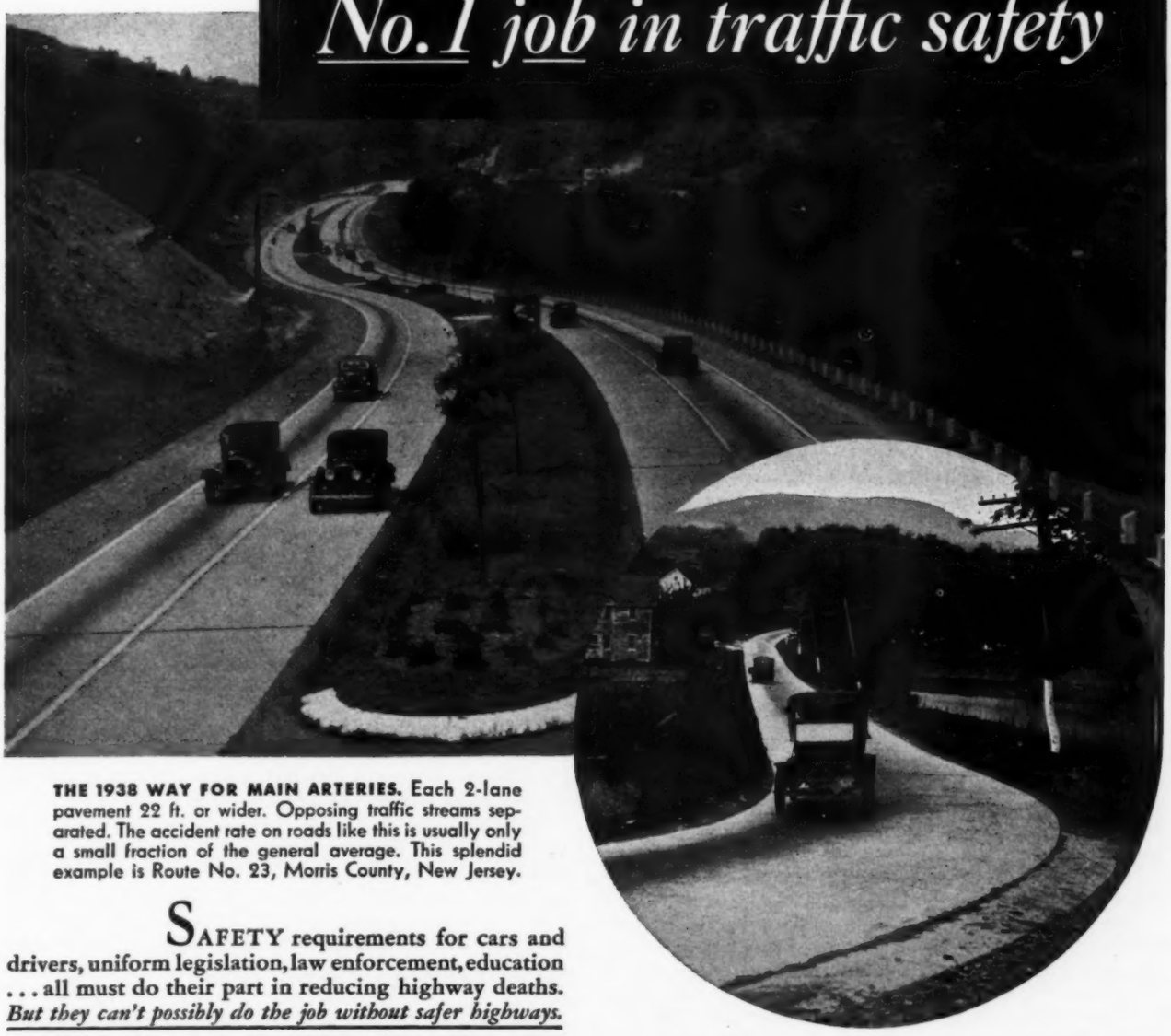
Under the discussion of volume of traffic, the quantity to be provided for was estimated at 5,750 vehicles in each direction, requiring a total of eight traffic lanes, each with a capacity of 1,440 vehicles per lane per hour. This estimate is the primary basis for the capacity ratings.

The capacity factor is divided into ten sub-factors, each with a sub-weight believed to be commensurate with its importance.

The capacity factor is divided into ten sub-factors as follows:

Separation of grades
Average speed obtainable
Capacity for buses on basis of desirable minimum of six lanes
Practicability of terminal connections
Efficiency of ramps, with respect to accelerating and decelerating lanes, grades and connections

Safer highways— No. 1 job in traffic safety



THE 1938 WAY FOR MAIN ARTERIES. Each 2-lane pavement 22 ft. or wider. Opposing traffic streams separated. The accident rate on roads like this is usually only a small fraction of the general average. This splendid example is Route No. 23, Morris County, New Jersey.

SAFETY requirements for cars and drivers, uniform legislation, law enforcement, education . . . all must do their part in reducing highway deaths. *But they can't possibly do the job without safer highways.*

All too often much of the blame for accidents must be placed on the road itself. It was too narrow; opposing traffic streams were not separated; there was inadequate sight distance at danger points; visibility was poor; the road surface was skiddy, high crowned, bumpy, irregular, raveled at the edges, or otherwise unsafe and confusing—defects which highway engineers can eliminate if given adequate funds.

Here's what can be done about it:

1. Design safety into highways by applying modern engineering principles.
2. Set up a rational plan for highway development that will eliminate congestion and danger spots.
3. Provide adequate funds and stop diversion.
4. *And build safe surfaces.*

THE 1918 WAY. 16 ft. was the prevailing 2-lane width. Highway engineers here and there were already beginning to break the shackles of tradition. But fence-corner turns and other hazards were still common.

Concrete provides the safest, most uniform and dependable "track" for motor vehicles that modern engineering has yet devised. Permanently even-contoured—skid-resistant in wet weather or dry—more visible, day or night. And concrete is *economical*: Costs *less to build* than other pavements of equal load-carrying capacity; costs far less to maintain.

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Access to property—parking facilities
Interference from mixed traffic
Alignment and grade of structure
Lane width (marginal friction)
Traffic separation (longitudinal)

Separation of Grades—The first and most important sub-factor is capacity as affected by separation of grades. The rating of this sub-factor is proportioned to the quantity of separation provided in each of the proposed plans, both as measured by the proportion of traffic, and the proportion of cross streets separated. Ten of the 14 projects provide complete separation and therefore receive the maximum rating. Three of the 14 projects provide no separation and are rated "zero." One project (the State Plan in Congress St.) provides partial separation. The State 12 hour counts of vehicles in the north and south streets crossing the line of Congress St. from Clinton St. to Central Ave. inclusive, total 181,000 vehicles. Of these about 149,000, or 82 per cent of the whole will be separated. The remaining 18 per cent will cross at grade with traffic-signal control. These figures give the quantity of separation provided for.

Average Speed Obtainable—The second sub-factor is "average speed attainable." The Committee fixed the desired average speed at 40 miles per hour, but it is not to be understood that the ratings fixed for the various proposed improvements are the proportion of this speed that may be obtained. It is, rather, the proportion of speed compared to that attainable on highways designed to permit maximum rate of movement. A number of the proposed improvements receive the highest possible rating. These are the highways with continuous grade separation and without contact with abutting property. (Limited ways.) Such highways will permit speeds beyond the 40 mile rate if not loaded beyond capacity, and if limited to the use of passenger motor traffic.

The third sub-factor weighs the adverse effect on capacity of parking along the edges of the express drives.

The fourth sub-factor, practicability of terminal connections, rates the possible freedom of movement of traffic in entering and leaving at the extremities of the improvement.

The fifth sub-factor (efficiency of ramps, accelerating lanes, etc.) measures the effect on capacity of the design of the ramps, and the benefit of accelerating and decelerating lanes where the same are provided. Plans Nos. 8, 11, and 13, for elevated highways in Monroe St., in Congress St., and in Polk St., are provided with ramps at right angles to the structures rather than with the more efficient type running parallel to the line of the main improvement. For this reason these three plans received the most severe penalty from the application of this sub-factor.

The sixth sub-factor (interference from mixed traffic) measures the adverse effect of the presence of truck and street railway traffic. But one project (Plan No. 6 for the widening of Madison St. at grade) is adversely affected by this rating. It is carline street and the committee believes that it is not feasible to prohibit trucks from the use of such streets.

The seventh sub-factor measures the effect on capacity of the alignment and grades provided. This rating adversely affects only Plan No. 12 (the State Plan for Congress St.) which is penalized for the rolling grades at the underpasses.

The eighth sub-factor measures the effect on capacity of the widths of lanes provided, and of marginal frictions other than those due to parking and to ramp connections.

The ninth sub-factor measures the effect on capacity of the lack of longitudinal separation of the roadways. Only Plans Nos. 6 and 13 (Madison St. at grade and Polk St. elevated highway) lack such separation.

The tenth and last sub-factor "capacity for buses on basis of desirable minimum of six lanes" indicates the opinion of the Committee that any major highway to be used for both private passenger motors and buses should have a minimum of three lanes in each direction, so that buses may load and unload without seriously affecting the flow of other motors.

The total rating for capacity for each plan is a product of the sum of the ten sub-factors discussed (which represents the capacity efficiency of the highway without reference to the number of traffic lanes provided) and the percentage of traffic lanes provided; the eight lanes required being 100 per cent.

The Location Factor

The location factor is divided into nine sub-factors, but I shall only discuss two of these sub-factors.

The first sub-factor is "Location With Reference to the Area Served; Efficiency of Position With Reference to Origin and Destination of Traffic." The assumption was made that the origin and distribution of traffic in the part of the district west of the river is substantially uniform over the area. This assumption is borne out by a study of the left and right hand movements from the east and west traffic flows, and by the fact that the district is closely built up in nearly all its parts. The relative traffic density north and south of Madison St. is indicated by the density of population. West of Halsted St. there are 166,000 people from Chicago Ave. to Madison St. and a population of 212,000 to Madison St. to Roosevelt Road (census 1930). From this assumption of equal density, the total number of miles that all vehicles in the area would travel to reach the line of any improvement was computed. The sub-factor ratings were proportioned to the computations, the highway requiring the least travel for use, of course, receiving the highest ratings.

The third sub-factor is "Availability of West Side Bridges to the Improvement." The Committee recognizes that an improvement may be built of a capacity sufficient to carry all of the expected traffic, but that this traffic cannot be discharged over any single existing river bridge or street leading from such bridge. Traffic from the improvement must be diffused over several bridges and several streets. As an example, the proposed Polk St. elevated highway (Plan No. 13) provides three traffic lanes in each direction, and these three lanes have an actual capacity of about 4,500 vehicles per hour. This improvement terminates at Canal St. The present Polk St., and the Polk St. bridge have a capacity in one direction of less than 1,000 vehicles per hour. It is obvious that the larger part of the traffic from the elevated highway would, of necessity, seek other bridges and other streets, and several of them, to make its way across the river, at least until such time as a further improvement of Polk St. east of the river be made.

The ratings for the several improvements as to availability of bridges, were made arbitrarily as follows: each existing or proposed west side bridge from Illinois St. to Polk St. was given a numerical value proportioned to its traffic capacity. Each was given a numerical value based on its distance from any improvement under consideration, the values decreasing with the increase of the distance. The product of these two values measured

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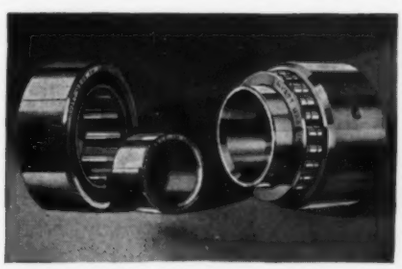
For all bearing requirements Hyatts outlast the mechanism of which they are a part . . . Because they are built to inconceivably precise standards of workmanship . . . Because they are made of the finest bearing steel . . . Because they are built to stand up under punishing speeds and loads. Consult the Hyatt Bearings Division, General Motors Corporation, Harrison, N. J., Detroit, San Francisco, or Hyatt Roller Bearing Sales Company, Chicago and Pittsburgh.

HYATT  **ROLLER BEARINGS**

the availability of each bridge to the improvement. The sum of the products for the several bridges measures the availability of all the bridges to the improvement.

The Financing Factor

Now let us consider the factor of feasibility of financing the improvement. There is a limit to the funds that may be raised to finance a major highway on the West Side, and a limit to the amount that properly should be spent to provide for the requirements of a single traffic district. The Committee set the sum of $50,000,000 ($5,000,000 per annum for 10 years) as being the maximum that could be possibly considered for expenditure. Ratings were determined on this basis. The ratings are proportioned to the costs of the several improvements, and decrease from a 100 per cent rating by 2 per cent for each million dollars of cost. For example, an improvement to cost $10,000,000 is rated 80 per cent—one to cost $50,000,000 is rated at "zero" per cent.

Now let us consider the factor of unit cost. The first sub-factor is cost per lane, and refers to the unit cost of the part of each improvement from Canal St. to Austin Ave. The cost west of Canal St. rather than the cost of the total improvements were used to permit an equitable comparison, as some improvements terminate at Canal St. and some are extended east over proposed bridges. The ratings are in proportion to the cost per lane, which is the total cost mentioned divided by the number of lanes provided, compared to an arbitrary standard of $2,500,000 per lane.

The second and last sub-factor is "maintenance and operating costs." Such costs may be determined only by elaborate estimates that would require much time to prepare. These costs, however, are to a large degree a function of total costs, and the ratings are in proportion to the total costs of the several improvements.

The aesthetic value of the improvement was given a weight of nine, and the adaptability of the improvement to stage construction was given a weight of three, but I shall not take time to discuss these factors. After setting up the rating table, the next step was to determine the volume of traffic expected on the improvement, and this volume of expected traffic is of obvious importance. It determines the widths of pavements required to remove the traffic and it is a major factor in determining the number of highways required, the type of structure, and the costs thereof. Before an estimate of traffic volume is made, however, it is necessary to decide as to the type of vehicles to be permitted to use the improvement.

Volume of Traffic Expected

The Committee, in its study to determine the volume of traffic that will make use of the proposed improvement did not include truck traffic volumes, as we believe that truck traffic should be excluded from the proposed improvement by regulation. The primary purpose of the proposed improvement is to move large volumes of passenger motor vehicles, and express buses to and from the central business district with safety and dispatch. The experience is that such purpose may be accomplished only by the complete separation of slow moving truck traffic from the passenger motor movements.

Motor traffic may be divided into two categories: the part that moves relatively short distances, and is local in character, and the part which may be designated as express traffic and that moves longer distances of perhaps three or four miles, or more. It is the latter class of traffic that seeks out and uses the better highways, those that permit a saving of time, and offer other advantages. Our estimate of expected traffic, therefore, deals largely with express traffic.

The area west of the central business district is now provided with highway facilities that are equal to or better than highway facilities in nearby west side districts, so that present traffic does not leave the district to seek better facilities but flows directly through it. In other words, the expected express traffic that will use the proposed improvement is the present express traffic in the area.

The West Side is provided with highways dedicated to the use of passenger motor cars only. These are the boulevards in Jackson, in Warren, and in Washington. The express passenger motor traffic is in these streets because their facilities for free-flow are by far the best in the area. Other streets (exclusive of Roosevelt Road) are not suitable for the movement because of worn and narrow pavements, and the presence of trucks and street cars. The expected express traffic on the proposed improvement is the express traffic now in the boulevards, with the additions to be stated hereafter.

A comprehensive and detailed count of traffic through the West Side, made by the State Highway Department in 1933, was available. This count includes a count on all east and west streets of the West Side of all vehicles, separated by types, for twelve hours, by 30 minute intervals, taken at the river bridges, at Canal St., at Halsted St., and at each section line street west of Halsted St. to the city limits. This count gives a complete picture of the traffic movement through the entire West Side.

In addition, the counts by the City Traffic Division were available to the Committee in similar detail. These counts are particularly complete as to vehicles entering and leaving the business district in all directions, and traffic volumes in all of the streets within the business area. It is to be noted that the State and City counts are in general agreement.

Determining Required Capacity of Highways

In determining the required capacity of a highway, the important thing is the maximum rate of flow in vehicles per hour, and this rate was used in our analysis. The improvement must, obviously, be of sufficient capacity to pass the peak loads that move through the district twice each working day. These peaks occur for about 30 minute periods. The homebound peak (westbound) is at somewhat the higher rate, as the morning is the better spread. At the river bridges the evening peak runs from 5 to 5:30 p. m., but the time of the peak is later as traffic moves west. These morning and evening peaks exceed the high-rate flows that are found on occasional Sundays and holidays.

The flow in the boulevards is 2,695 vehicles per hour at Halsted St., increasing to a maximum of 3,500 vehicles at Ashland Ave. It decreases to 3,405 vehicles at Kedzie Ave., to 3,135 vehicles at Pulaski Road, and to 2,685 vehicles at Cicero Ave. It will be noted that the maximum flow of 3,500 vehicles per hour at Ashland Ave. is the measure of the expressed flow in the boulevards. Part of this maximum flow of 3,500 vehicles per hour in Jackson and Washington boulevards is local traffic. We include this local traffic in our estimate, however, as it is to be expected that some local traffic will be found on the express lanes of the proposed improvement.

The total of 3,500 vehicles in the boulevards, plus the diversion of 150 vehicles from Roosevelt Road, and 100

Just Off the Press

ENGINEERING TERMINOLOGY

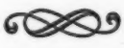
DEFINITIONS OF TECHNICAL WORDS AND PHRASES

BY

VICTOR J. BROWN, C. E.
Publishing Director
Roads and Streets

AND

DELMAR G. RUNNER, A. B., A. M.
Assistant Materials Engineer
U. S. Bureau of Public Roads



This new book, the first of its kind, is designed to give a clearer understanding of technical words and phrases as they are used in different branches of engineering. Over 5,000 definitions in this 320-page book are exceptionally useful to all who have any contact with engineering works, contracts, specifications, articles or discussions. It is illustrated in order to help convey the idea of certain definitions. No student, lawyer, engineer, contractor, judge, executive or salesman should be without it. Engineering Terminology is to the executive and engineer what a hammer is to a carpenter.

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Most of the included definitions have been approved by recognized technical societies and associations.

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vehicles from Chicago Ave., makes a total of 3,750 vehicles per hour. In addition to the private passenger motors there are 75 buses per hour in Jackson and Washington Blvds. during the peak flow. This gives a total of 3,825 vehicles per hour as the estimate of present expected flow on the improvement in one direction. This estimate is liberal, as it carries the assumption that all express traffic in Jackson Blvd., Warren Ave. and Washington Blvd. will leave those boulevards to use the proposed improvement.

Looking into the future, it was proposed that the present day traffic volume be arbitrarily increased by 50 per cent to provide for traffic up to the year 1950. This allowance for future increase of traffic will increase the estimate of expected traffic volume from the present 3,825 vehicles per hour to 5,700 vehicles per hour in the year 1950 for the flow in each direction.

Having estimated the volume of traffic to be expected on the proposed improvement, the next step is to determine the total width of pavement necessary to carry be incorporated into a single highway or into two or such volume, and whether or not such total width may more.

The unit of highway is the traffic lane, and is a strip of pavement of sufficient width to permit the flow of a single line of vehicles. The traffic lane is nominally 10 ft. wide. If the number of vehicles that can pass over a single lane in a given time is known the total number of traffic lanes required is, of course, the volume of traffic to be moved, divided by the capacity of a single lane.

The capacity of a traffic lane may be determined by the count of vehicles moving on existing highways when the volume of traffic is sufficient to load the highway to capacity. The volume of traffic passed by one highway may, of course, be passed by any other of like dimensions and similar characteristics.

A study of the Lake Shore Drive extension north of Byron St. indicated that the capacity of this highway could be placed at 1,700 vehicles per lane per hour at 40 miles per hour under normal conditions (dry) of road surface. This rating is the average capacity of each of the four lanes. A study of North La Salle St., from North Clark St. to Kinzie St., indicated that this highway has a capacity of 1,000 vehicles per lane per hour, with a speed approximately 25 miles per hour.

The number of traffic lanes required is obtained by dividing the expected traffic volume by the traffic capacity of a single lane. Our estimate for expected traffic on the West Side improvement is 5,750 vehicles per hour in one direction in the year 1950. The range of capacity of a single lane has been stated as more than 1,000 vehicles per hour, up to somewhat more than 1,700 vehicles per hour, depending on the characteristics and the use of the highway. If four traffic lanes are provided in each direction on the proposed West Side highway, the average capacity of each lane must be 1,440 vehicles per hour to pass the total volume of 5,750 vehicles. Thus we must provide a highway of a capacity of more than the one in North La Salle St., but it need not be equal to the maximum capacity of the one in Lake Shore Drive north of Byron St. The Committee agreed upon this standard of 1,440 vehicles per hour per lane, and a standard speed of 40 miles per hour.

Based on all the foregoing study and analyses, the committee set up in its report a so-called "Rating Table." This rating table shows the factor designated as determining the value of each improvement, the sub-factors into which the main factors were divided, the weight applied to the factors and to the sub-factors, the numerical values determined by the committee for each of the main and sub-factors and finally, the total numerical rating for each plan. The ratings and percentages of a possible maximum of 100 points.

The project having the total highest rating was an eight-lane highway, partly elevated and partly at grade, with a total overall weight of 74.05 out of a possible 100.

This highway rated 7th as regards safety of design, 4th as to safety compared to the proportion of traffic handled, fourth as to capacity, and second as to location.

Acknowledgment—The foregoing is a paper presented March 15 before the Western Society of Engineers.

▼

BOOK REVIEW

Engineering Terminology, *Definitions of Technical Words and Phrases,* by V. J. (Vic) Brown, C.E., Publishing Director of Roads and Streets, and D. G. Runner, A.B., A.M., Assistant Materials Engineer, U. S. Bureau of Public Roads. Page size, 6 in. by 9 in.; 310 pages, illustrated; hard buckram binding. Price, $3.50 plus postage. Gillette Publishing Co., 330 S. Wells St., Chicago, Ill.

In this book the authors have collected from authoritative sources, definitions of technical words and phrases as used in all branches of civil engineering. The authors realize that the book is not as complete as an unabridged dictionary, but they have, nevertheless, included terms not found in an unabridged general dictionary.

There has long been a need for such a book. This volume covers such subjects as the following:

Highway Construction, Geology, Petrology, Architecture, English-Spanish Words, Useful Information, Conversion Factors, Tables of Chemical Elements, Their Symbols and Atomic Weights; Appraisal Terms, Bridge Nomenclature, Highway Maintenance; Steel, Slag, Rock, Gravel; Hydraulics, Compressed Air, Soil Types Classified and Defined, Railway Terms, Water Works and Sewerage, Hydraulic Symbols, Technical Abbreviations, Surveying, Spanish-English Words, English-German Words, Standard Engineering Symbols and Abbreviations; Conversion Tables °F to °C and Vice Versa; Contracts and Appraisals, Pump Designations and Types. Pump Materials for Pumping Various Liquids, Sewage, Investments.

Diction is not included but the definitions are those recognized and approved by committees of the many technical societies and associations.

▼

Brownmiller Appointed Secretary of Highways of Pennsylvania

Roy E. Brownmiller, Deputy Secretary, has been appointed Secretary of Highways, State Highway Department of Pennsylvania, succeeding the late Warren Van Dyke. Mr. Brownmiller was appointed deputy secretary April 1, 1935, and was selected by Mr. Van Dyke with whom he was closely associated for the past 16 years. The new Secretary of Highways has had a notable career of public service. Since 1922 he has served one term in the State House of Representatives and three terms as Schuylkill County commissioner, winning every elective office to which he had aspired. Before entering public life, Mr. Brownmiller was employed in the industries of his home county. Leaving school upon completion of the grammar grades, his first job was with his father who operated a marble and granite cutting business in Schuylkill Haven. After 10 years in this labor, he worked for the American Express Company and then entered the employ of the Philadelphia and Reading Railway Company as a clerk in the motive power and rolling equipment department stationed at St. Clair.

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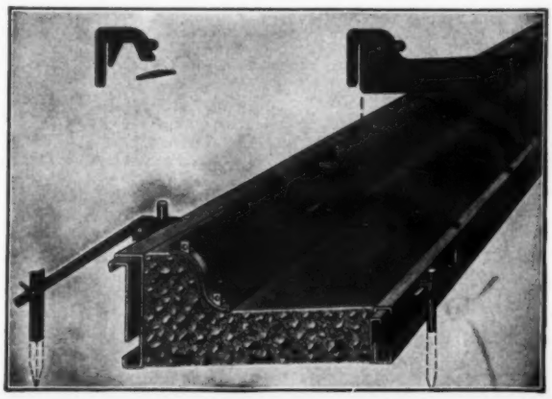

Illustration shows a combined curb and gutter unit with a double radius face rail. The division plates support the front and back forms to their full depth, the face rail is securely keyed to the division plates and the whole structure is locked in place by stakes of sufficient length to secure maximum stability. The face rails may be removed as soon as the concrete is set without disturbing the side forms, permitting curb and gutter construction with relatively few face rails.

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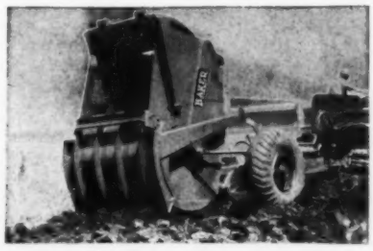

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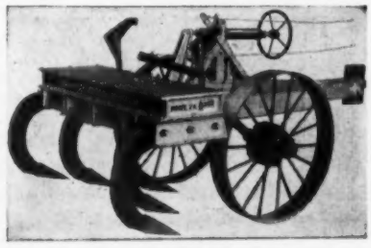

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By LEON GOTTLIEB

Bituminous Engineer,
Alabama State Highway Department

IN order to produce a better finished surface from several standpoints, the Alabama Highway Department started experimenting in 1935, using low cost pre-mix material for a finish coat of our inverted penetration surfaces.

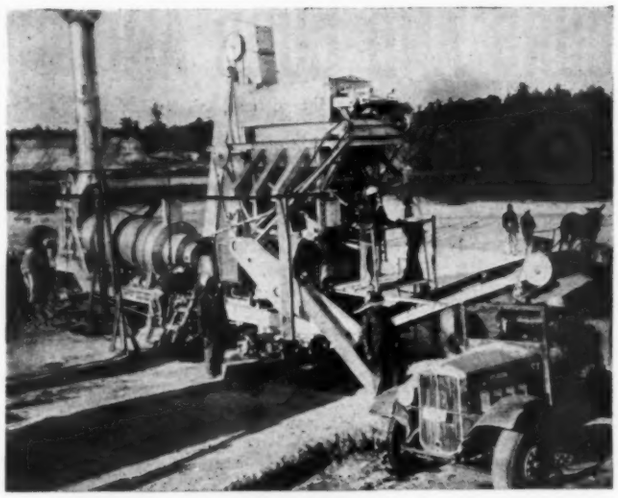
The first work consisted of road mixing sand for the seal coat, but it was found that due to the large surface area of voids in the inverted penetration (one layer of 1 in. aggregate), too much of the sand remained in the voids of the large aggregate and could not be coated with bitumen. The next step was to develop a satisfactory method for mixing the seal coat material without the necessity of using large asphalt plants for the small tonnage of material involved on each project. At about that time we had purchased several small maintenance mixing units which were known as cold patch mortar mixers. We then started using these mixers for mixing our seal coat materials. In so doing we often are obliged to use wet aggregates, proportion them by volume, using wheelbarrows, and measure the asphalt or tar by volume in improvised cans or buckets. With some refinements this method is still being used in all divisions.

After observing the work being done for two years it was decided to purchase a portable asphalt plant in an effort to reduce the cost and secure a better mixed product. Last October the Highway Department purchased a Speed-line portable asphalt plant from the Iowa Manufacturing Co. This plant is a completely portable one-unit drying and mixing plant and can be moved from one location to another by pulling with trucks. The plant is rated as a 1,000-lb. pug mix size and is the proper size plant for our type of work.

This plant is located at Spruce Pine, Alabama, and before operations were suspended last fall due to climatic conditions we had sealed over 20 miles of road. During the winter months we have used the plant to mix maintenance patching material. The plant mix used for the seal work consisted of a mixture of local sand, crushed limestone and bitumen.

The plant was erected in the sand pit. The limestone was hauled to the plant site from the stone quarry located about 5 miles to the north. The sand and crushed limestone were piled close to the cold elevator first by slip scrapers and later by a tractor and La Tourneau scrapers. The sand and stone was then fed to the elevator by convicts, using shovels, in the proportions of 3 parts sand to 1 part limestone. The sand usually contained about 10 per cent to 12 per cent moisture. The material was sent through the drier and released to the hot elevator at a temperature of about 250° F. and with the moisture content reduced to about 1 per cent, which was considered satisfactory. From the hot elevator it was taken over a vibrating screen where the material was separated through the No. 10-mesh sieve and dropped into the storage bins. From there it was released as needed and weighed in the mixing chamber, using 1,000 lb. of the combined aggregate to 55 lb. of asphalt.

To date we have used AC-15-150 to 180 penetration asphalt; MC 3, and MC 4 slow curing cut-back asphalt,



Set-up of Asphalt Plant at Spruce Pine, Ala.

and all sections appear to be satisfactory. The material was mixed about one minute and the plant has mixed as high as 300 tons per day.

The mixed material was hauled by trucks to the road and spread in place with an Adnun spreader. It was then rolled with a 7 to 10-ton variable weight Galion roller.

The specifications for the pre-mix material is as follows:

Total Passing	Percentage by Weight
½-inch sieve	100
⅜-inch sieve	85 to 100
No. 4 sieve	40 to 90
No. 10 sieve	20 to 60
No. 40 sieve	5 to 30
No. 200 sieve	0 to 8
Bitumen	5 to 8

On the road, the inverted penetration or surface treatment was first swept to clean the surface of all loose material. Then a tack coat of 0.08 to 0.10 gal. per square yard was applied. The tack coat material was usually the same grade as the material used in the mix, except that when the AC-15 was used in the mix, the tack coat was MC-3. After the tack coat was applied an Adnun spreader was used to spread the mix. The pre-mix material was dumped from the trucks directly into the hopper of the spreader and the machine was set to spread an average of 40 lb. of pre-mix material per square yard. The Adnun spread the mix 10 ft. wide. At some convenient point three or four times a day the Adnun was backed to spread the remaining 10 ft. of pavement. In order to eliminate the joint in the center of the road about 6 in. of the first spread was left unrolled and blended with the material from the second half spread before the joint was rolled.

The material made in the above mentioned asphalt plant is more uniform in texture and can be mixed using less bitumen and heavier grades of bitumen than with the use of the cold patch mixers. Also by using the dry aggregate we avoid "stripping of the asphalt" from the mixed material as often occurs when the wet aggregate mixes are used and the freshly placed mixtures are rained on.

This type of construction appears to offer the best solution for a finished wearing surface for several reasons. It fills the voids in the larger aggregate of the surface treatment, thereby providing a closer textured but non-skid wearing surface which prevents excessive wear on the coarse aggregate and also produces a sur-

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face that does not wear the tires of the motor vehicles so rapidly. It serves to strengthen and slightly build up the thickness of the surface treatment and by precoating the aggregate helps to prevent the wear of traffic on the softer aggregates. It may also have a tendency to make the entire wearing surface more impervious, thereby preventing any water from leaking through the surface to the base course, which is constructed of selected graded earth materials in which the percentage of clay, silt, sand and aggregate are controlled to fit the local material available.

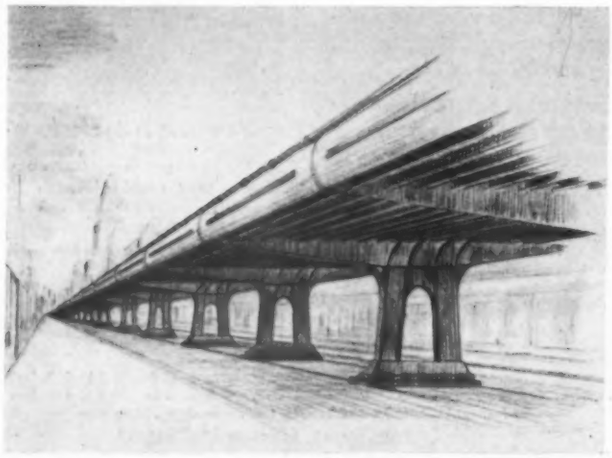
▼

American Institute of Steel Construction Awards for Elevated Highway Designs

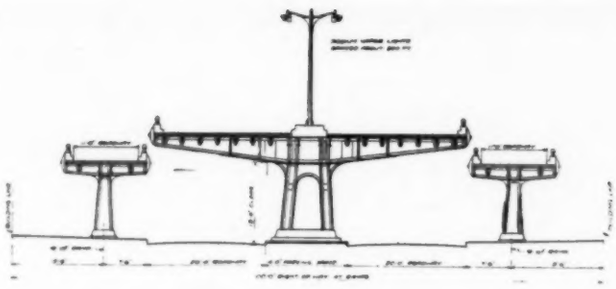
Hazelet & Erdal, Consulting Engineers, Chicago, Ill., were the winners of the first prize, $5,000, in the recent competition of the American Institute of Steel Construction for design of an elevated highway for relieving congestion and speeding the flow of traffic through densely populated cities. In all 273 designs were submitted in the competition. Most of these were the result of collaborative work on the part of architects and engineers. Among the foreign designs submitted were four from Paris, France, and designs from London, England; Stockholm, Sweden; Haarten, Holland; Budapest, Hungary; Shanghai, China; Caracas, Venezuela; Vancouver, British Columbia, and Montreal, Province of Quebec, Canada.

The design of Hazelet & Erdal was for a streamlined structure supporting a 4-lane roadway upon a cantilevered floor beam supported on a central bent the spread of the legs of which is sufficiently close not to impinge upon, but forms a center safety zone upon the street below. Such a design, it was felt, could be erected without causing consequential property damage and without impeding traffic on the underlying street.

Mr. Hazelet is a graduate of the University of Washington, and of Massachusetts Institute of Technology. Bridges of his design can be found in many countries of the world. Before joining Mr. Erdal to constitute the present firm, Mr. Hazelet was with Boston & Albany Railroad; the firm of Fay, Spofford and Thorndyke of Boston, and the Ford Motor Company of Detroit. Mr. Erdal is a graduate of the Technical College of Trondhjem, Norway. He worked as bridge designer for the Chicago, Burlington & Quincy Railway and the American Bridge Company.



Sketch Showing Prize-Winning Design of Hazelet & Erdal.



Section of Prize-Winning Design of Hazelet & Erdal.

The second prize of $2,000 went to Madigan-Hyland, consulting engineers of New York, E. H. Praeger, Chief Engineer, and C. F. Lloyd, Architectural Designer. The design they submitted was that actually built for that portion of the new Henry Hudson Parkway between St. Clair Pl. and 135th St., New York. Madigan-Hyland are consulting engineers for the Department of Parks under Robert Moses, Commissioner; and the New York Central Railroad in the design of the New York Parkway which extends from 72nd St. to the City Line. This firm has also acted as engineers for other parkway projects under Mr. Moses, namely, the Marine Parkway, the Bronx-Whitestone Parkway, and the bridges and the preparation of the site of the Flushing Meadows Park.

The third prize of $1,000 went to Walter W. W. Jones, a Civil Service employe with the title of Engineering Illustrative Designer, Department of Borough Works, Office of the President, Borough of Manhattan. His work consists of designs for the many new improvements in Manhattan that are contemplated by this Department, such as the East River Drive, Fulton Fish Market and 96th St. Transverse Road. He worked on many of the recent improvements in the city's parks and parkways including the West Side Improvement, Henry Hudson Parkway, Jacob Riis Park, several zoos and playgrounds. Mr. Jones was graduated from Rutgers University in 1925 and has received additional training at Pratt Institute, College of the City of New York and the Beaux Arts Institute of Design.

The jury awarded Honorable Mention and $100 in cash to each of ten other designs. Two of these designs were submitted by B. K. Johnstone and L. A. Richardson, Pennsylvania State College, State College, Pa. The other designs winning honorable mention awards were submitted by: F. Dougherty, W. G. Moeckel and L. H. Doane of Wilmington, Dela.; Charles M. Noble, A. Gordon Lorimer and Milton Brumer of New York, N. Y.; Hays, Simpson, Hunsicker of Cleveland, O.; E. L. Pavlo of White Plains, New York; Max Schlesinger, Division of Highways, Springfield, Ill.; Owen Lane Gowman, New York, N. Y.; George D. Recher, Chicago, Ill.; G. S. Underwood and W. E. Reynolds, Washington, D. C.

▼

59 Per Cent of Motor Vehicle Travel on Main Highways—The road-use surveys in 17 states show that 58.9 per cent of total annual motor vehicle travel on all roads and streets occurs on main rural highways and the streets than connect them through cities. Of the balance, 30.8 per cent occurs on the large mileage of other city streets; and scarcely more than 10 per cent of the total occurs on secondary and local rural roads, which represent eight times the mileage of primary highways.

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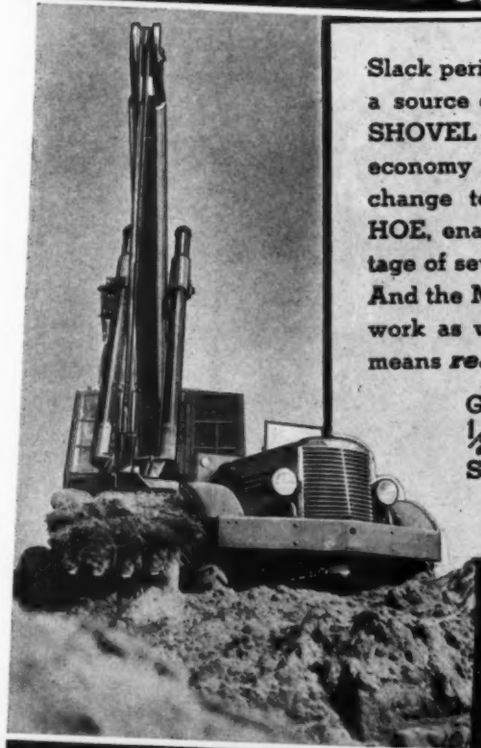


Slack periods between your larger jobs become a source of profit with a MICHIGAN TRUCK SHOVEL-CRANE. The truck-mobility and economy of the MICHIGAN, plus its quick-change to DRAGLINE, CLAM or TRENCH HOE, enables you to take ***profitable*** advantage of several "in-between" jobs at a time. . . . And the MICHIGAN is always ready for steady work as well, where its high operating speed means ***real production.***

Get the complete facts on the versatile ½ yd. and ⅜ yd. MICHIGAN TRUCK SHOVEL-CRANE.

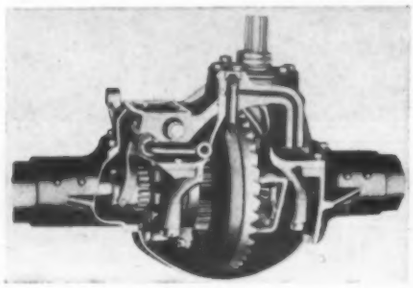
Write for Bulletin "RS"

MICHIGAN POWER SHOVEL Co BENTON HARBOR, MICHIGAN, U.S.A.

NEW EQUIPMENT AND MATERIALS

Ford V-8 Trucks with Two Speed Axles Announced

Designed for a wider range of operating requirements, 2-speed-axle-equipped Ford V-8 trucks, have been announced by the Ford Motor Co. The 157-in. and 134-in. wheelbase trucks is offered with this special Ford axle. The 191-in. wheelbase school bus chassis will also be available with it. The new trucks will have eight forward speeds and two in reverse. Gear ratios which closely fit varying load and road conditions are thus provided. The new Ford 2-speed rear axle has virtually the same basic features of design as the conventional Ford truck axle. The pinion shaft is straddle-mounted with two large tapered roller bearings in front of the pinion and a straight roller bearing directly behind it. Differential side bearings also are the tapered roller type. One notable feature is that in the reduction only four additional moving parts are in operation. A simplified planetary system of gearing is used to obtain the reduction. Shifting from one axle ratio to the other is easily accomplished by means of a lever mounted at the left inside the cab. When this lever is in



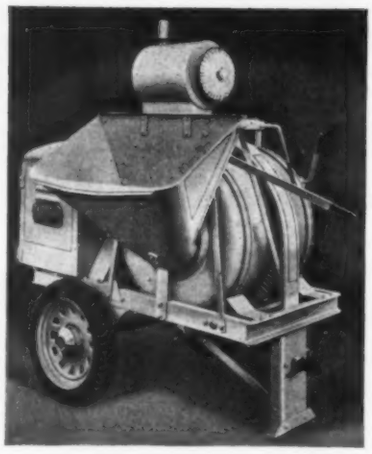
The New Ford 2-Speed Rear Axle

its forward position, the axle operates the same as a conventional rear axle. With the lever in this position, the pinion shaft makes 5.83 revolutions to one revolution of the wheels when the 4-speed transmission is in high and 37.3 revolutions to one when the transmission is in low speed. When the control lever is moved to its rearward position, it operates a sliding clutch in the two-speed axle housing which brings a lower gear ratio into operation. The drive shaft pinion then makes 8.11 revolutions to one revolution of the wheels when the 4-speed transmission is in high and 51.9 revolutions to one in low. A novel method of forced lubrication has been incorporated in the design of the axle which provides positive lubrication to all bearings.

▼

New High Capacity Small Mixer

A new light weight non-tilt trailer mixer has been added to the line of the Jaeger Machine Co., 223 Dublin Ave., Columbus, O. The high capacity in this small mixer is stated to be due to the measuring batch hopper, which is of same capacity as the drum, may be loaded while the previous batch is being mixed and discharged, thus eliminating waiting between batches as well



Jaeger "Handy" Utility Mixer

as saving the cost of a power loader. Drum design is identical with that of larger Jaeger mixers, employing a criss-cross remixing action. Buckets are unusually large for fast discharge into forms or barrows. Chilled drum rollers operate on ball bearing shaft. Water tank is syphon type, of 7 gal. capacity, with quick setting dial. All controls are grouped on side opposite from engine, which is 2½ H.P. fully enclosed. Pneumatic tires, Timken bearings, spring shock absorbers and disappearing towing pole equip mixer for trailing at unlimited speeds behind light cars.

▼

New Bucket Loader

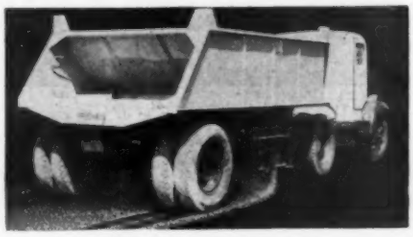
A new full crawler-mounted, high capacity, self-feeding bucket loader to be known as the Model 552, has just been announced by Barber-Greene Co. of Aurora, Ill., manufacturers of standardized material-handling machines. The bucket loader has many advantages contributing to its high speed and low cost operation. It operates continuously, giving a steady flow of material. Its spirals are self-feeding. Its operation is simple and is quickly learned by any truck driver. The bucket loader, being full crawler-mounted, is quickly moved from one set-up to another within the yard or pit, and its boom may be laid back for low traveling clearance for covering greater distances. The new Junior Bucket Loader has many features, including the tank type chassis frame, synchronized spiral feed, automatic overload release, optional high traveling speed or slow crowding speed. The 552 incorporates the B-G Patented Floating Boom principle.

New Model 552 Junior Bucket Loader

▼

New Gravel Spreader

A new gravel spreader has been introduced by Fruehauf Trailer Co., 10940 Harper Ave., Detroit, Mich., well-known builders of a wide range of trailer equipment. This unit spreads not only gravel, but cinders, sand, crushed rock, etc. It has an 8-cu. yard body, is strongly reinforced throughout, and weighs only 5,200 lbs. fully equipped. This saving in weight has been accomplished through elimination of any mechanical lifting device and through the substitution of a special body. The gravel spreader allows a flow of material adjustable from ½ in. to 7½ in. and the specially-designed discharge gate is stated to enable the flow to be shut off instantly, without seepage. This discharge gate can be operated either by hand, vacuum, or air—and can be cab-controlled to permit one man operation. Spread is even and continuous. Although primarily intended for spreading purposes, this unit can also be used to advantage for transport hauls in operations where the load is to be dumped into a hopper. Eight-inch corner brackets allow installation of top boards when greater loads of lighter materials are desired. The unit is equipped with 9.00/20 10-ply dual pneumatic tires, Westinghouse air brakes, main and auxiliary springs, supports, I-Beam axle, and is electrically welded throughout.



New Fruehauf Gravel Spreader

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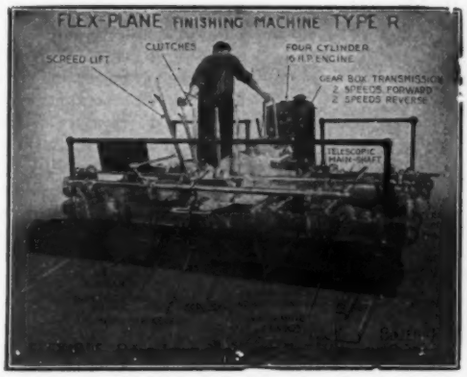
New Engine Driven Concrete Vibrators

A new line of gas-engine driven internal concrete vibrators, has just been brought out by the Syntron Co., 384 Lexington Ave., Homer City, Pa. Each outfit is complete, made up of an engine, flexible shaft and vibrating tool. The engine is a 3-H.P. air cooled, 4-cycle Wisconsin with automatic clutch, power take-off and all accessories. The illustration shown the engine mounted on a pneumatic-tired, wheelbarrow chassis. It is also available mounted on a swivel pedestal base. The flexible shaft is of the finest quality, heavily armored, and comes in 12 ft. and 7 ft. lengths, complete with simple threaded, positive couplings. As long as 31 ft. drives can be used. The vibrating tools are in two sizes: 1⅝ in. by 18 in. and 2⅝ in. by 18 in., made up of strong steel cylinders, sealed against leakage, with an unbalanced shaft inside mounted in heavy

"MORE and MORE"


FLEX-PLANE FINISHING MACHINE TYPE R
SCREED LIFT
CLUTCHES
FOUR CYLINDER 60 H.P. ENGINE
GEAR BOX TRANSMISSION 2 SPEEDS FORWARD 2 SPEEDS REVERSE
TELESCOPIC MAIN SHAFT

Tennessee, Georgia, South Carolina and Indiana have joined the long list of States using ribbon dummy joints. Ribbon is only 1/8" thick—little shrinkage—water-tight and lasts as long as the road.

FLEXIBLE ROAD JOINT MACHINE COMPANY
WARREN, OHIO

We Also Build Popular Priced, Tractor Drawn Model for Light Retread and Stabilized!

Mix-in-Place ROAD BUILDER

Gives a better mix and smoother surface to heavy mat or stabilized base—IN ONE PASS! Send for Catalog and actual job records.

THE JAEGER MACHINE CO., 223 Dublin Avenue COLUMBUS, OHIO

21 Ft. Straight Edge Levelers Insure Smooth Surface!

Check in at DeWITT OPERATED HOTELS

In CLEVELAND it's The HOLLENDEN

In COLUMBUS it's The NEIL HOUSE

In AKRON it's The MAYFLOWER

In TOLEDO it's The NEW SECOR

In JAMESTOWN (New York) it's The JAMESTOWN and The SAMUELS

and featuring

Unusually Comfortable, Modern Rooms; Good Food, Carefully Prepared and Served; Every Modern Hotel Facility and Reasonable and Uniform Rates

"Genuinely Friendly"

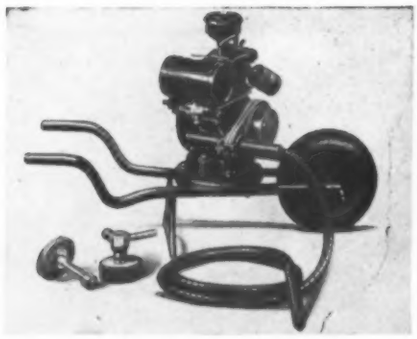
Built to do a . . . BETTER JOB!

Sturdy construction combined with many modern and exclusive features of design account for Huber's lower operating costs—lower maintenance—plus the extra speed which enables it to do a better job in less time. Huber Road Rollers invite comparison. Buy by comparison—and you will buy a Huber. Write for Bulletins describing these modern machines in detail.

The HUBER MFG. CO.
Marion, Ohio

6 Sizes from 5 to 12 Tons Gasoline or Diesel.

Buy a HUBER



New Syntron Engine Driven Vibrator

oversize ball bearings. Their speed of vibration ranges from 3600 to 6500 r.p.m. and is controlled through the adjustable speed governor on the engine. Complete catalog information including a treatise on the vibration of concrete is available from the manufacturer.

▼

New Stabilizer Plant

A new stabilizer plant for mixing aggregate, clay, water, and calcium chloride or salt has been brought out by the Pioneer Engineering Works, Inc., 1515 Central Ave., Minneapolis, Minn. This plant is complete on one truck and is designed for operating out of stockpiles. Two receiving hoppers are furnished—one for the gravel or aggregate and the other for the clay. A mechanical feeder under the gravel receiving hopper feeds a uniform amount to the gravel conveyor and into the pugmill. A screw type feeder under the clay hopper measures the correct amount of clay onto the clay conveyor, then thru the clay shredder and into the pugmill. A hopper and feeder measures the calcium chloride or salt and feeds it onto the clay conveyor. Water is pumped from a storage tank alongside of the plant and sprayed onto the material in the pugmill. The folding delivery conveyor on the right (see illustration) delivers the finished product into trucks which carry it to the grade.

Pioneer No. 73 Stabilizer Plant on Job of West Michigan Construction Co.

A New Hand Rotated Stopehamer

A new hand rotated Stopehamer known as the "SA-90," has been introduced recently by Ingersoll-Rand Co., 11 Broadway, New York City. This machine embodies several new features of design. The piston is similar in outward appearance to that customarily used in jackhamers and drifters. It is solid except for the water tube hole and combines the advantage of long wearing surfaces of the Jackhamer type piston with the rugged resistance to breakage of the so-called block type piston. The throttle valve is stated to be a radical departure in rock drill design. It consists of two circular plates held together by air pressure. This is one of the advantages claimed for the taper type throttle. At the same time this SA-90 throttle retains the ease of operation of the straight throttle. The large wearing surfaces materially increase the life of this part. The fronthead is of the shrouded type overlapping the cylinder and increasing the rigidity of the drill at this point. The entire front end of the drill, including front cylinder washer, is equipped with easily and quickly renewable bushings on all wearing surfaces. The new, double opening, direct flow main valve is claimed to be responsible for the low air consumption and high drilling speed of this stoper.

SA-90 Stoper

▼

New Floodlights

For floodlighting of construction projects, athletic fields, sports areas, service stations, and industrial yards, types AH-14, AH-16, AH-20, AVH-16 and AVH-20 floodlights have been designed by the Lighting Division of Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa. Ease of maintenance, relamping, cleaning or servicing are claimed as characteristic of these floodlights because of their dust-tight and moisture proof cover doors. The cast aluminum door is hinged at the bottom of AH reflector and at the top of AVH reflector. The reflector is spun from Alclad aluminum and is either etched for a wide beam or polished for a narrow beam and then treated by the Alzak process. The same socket housing and mounting brackets are used on all type AH floodlights so that interchanging reflector sizes or types to meet changing applications and also economical replacement of damaged reflectors or socket housings is possible. The socket housing is heavy cast aluminum, attached to the reflector by four bolts and a heavy steel reinforcing cup. The mounting bracket is a galvanized steel bow for cross-arm mounting. Suitable bases to be attached to the steel bow are available for slipfitter, pipe clamp, or flat surface mounting. The lenses are of all plain, heavy stippled, high transmission, and heat resisting glass.

▼

New Supercharger

Application of supercharging in the low-priced truck and car field is an innovation brought about by the perfection of a supercharger unit at moderate cost, according to the Milwaukee manufacturer of a new improved supercharger for Ford V-8 motors. This unit it is claimed now opens the way for adoption of super-charging all recent models of the Ford V-8 to secure advantages claimed by the manufacturer of a step-up from 85 to 124 H. P., an increase in gasoline mileage from 7.3 per cent to 19.7 per cent, smoother performance, less engine wear and longer bearing life. While the popular idea on increased power is usually translated into terms of speed, quick acceleration, easier handling in traffic and plenty of reserve, the advantages of supercharging in today's market, as pointed out by the manufacturer, also include the power for pulling trailers, for driving where going is tough, and for overcoming the power loss in mountainous sections where each 1,000 feet of altitude accounts for a loss of from 3 to 5 per cent. This super-charger, simplest terms, is a pump

Showing Installation of Super-charger

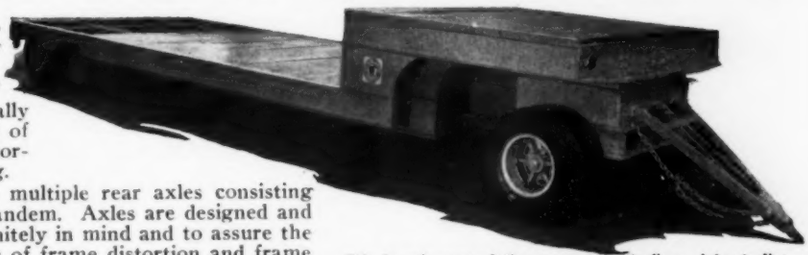
JAHN TRAILERS ARE BUILT TO TAKE IT!

HERE is a trailer with a combination of advanced engineering features especially suited for heavy-duty service.

Look at the double reinforced "goose-neck" construction. This, combined with an unusually rigid "X" type frame, eliminates any possibility of frame sagging or kingpin failure. Recessed flooring protects ends of planking from splintering.

Equal load distribution is accomplished by multiple rear axles consisting of four oscillating type axles placed in dual tandem. Axles are designed and built with the problems of frame stresses definitely in mind and to assure the proper distribution of load and the elimination of frame distortion and frame failure.

If you're in the market for a heavy-duty machinery trailer, don't fail to investigate the features these trailers offer. Write or wire—



This is only one of the many Jahn trailers. Jahn trailer designs include complete combinations of wheel arrangements for every type of load, from 5 to 100 ton capacities.

"Come to Trailer Headquarters"

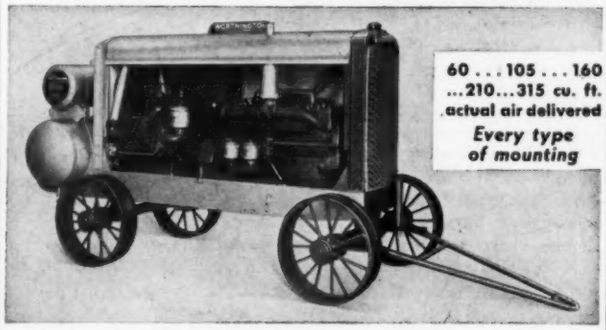
C. R. JAHN COMPANY, 165 W. Wacker Drive, Chicago, Illinois

Did You Know That—

IF PLACED END TO END
THE 372 GREAT ROADS OF THE ANCIENT ROMAN EMPIRE WOULD MORE THAN TWICE CIRCLE THE WORLD AT THE EQUATOR.

WORTHINGTON

PORTABLE COMPRESSORS
ROCK DRILLS • CONTRACTORS AIR TOOLS



60 . . . 105 . . . 160
. . . 210 . . . 315 cu. ft.
actual air delivered
Every type of mounting

Worthington Air Tools are further aids to profitable operation

● *Sold and rented by leading dealers*

WORTHINGTON PUMP AND MACHINERY CORPORATION
General Offices: HARRISON, NEW JERSEY

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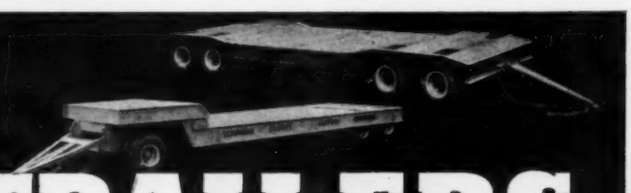
LA CROSSE Heavy Duty TRAILERS



The most complete line on the market. Capacities, five to two hundred tons. Four to sixteen wheels. Two to eight axles. They are built to take the heaviest loads safely, and with the least damage to road beds. Write today. Just tell us what you have to move.

THE LARGEST TRAILER IN THE WORLD IS A LA CROSSE !

LA CROSSE TRAILER & EQUIPMENT CO., LA CROSSE, WIS., U.S.A
DIVISION OF LA CROSSE BOILER CO.

used to increase the amount of gasoline and air mixture which can enter each cylinder of the motor during the intake stroke of the piston. Atmospheric pressure, even at sea level, is not great enough to fill the cylinders with the most efficient charge even at low speeds. At high speed, this condition becomes even more exaggerated. To overcome this problem, the pump or blower raises the pressure of the incoming mixture, increases the speed with which it passes into the cylinders and results in a super-charge to create super-power. As shown in the illustration, the super-charger is easily installed between the carburetor and the intake manifold and, according to the manufacturer, it does not change the motor's basic engineering. Applications include cars and trucks, marine conversions and industrial power units.

▼

New Steam Tank Car Heaters

The Cleaver-Brooks Co. of Milwaukee, Wis., has joined the ever-increasing group of manufacturers who are building into their equipment modern artistic design as well as the utmost utility. The accompanying cut, showing the 1938 Model Cleaver tank car heater, illustrates what can be done in artistic effect with even such a prosaic subject as a steam boiler. To the modern styling of the new Cleaver steam tank car heater has been added new and important savings in operation, the result of many years of experience in the heating of bituminous materials in tank cars. Under the steel covering is a highly efficient, oil burning steam generating plant of the horizontal fire tube type, especially designed for burning fuel oils. The burner atomizes the fuel and a gasoline driven blower furnishes the correct amount of air at the correct pressure to provide complete combustion. The gases are then forced four times downward through a long gas travel, resulting in a highly efficient unit. Insulation is furnished around the boiler shell, to prevent heat losses and over this is the streamlined sheet steel lagging. The oil burner and other operating machinery is also covered by sheet steel housing. The unit is self-contained and is mounted on a high speed, roller bearing, rubber tired trailer for quickly moving from one location to another. When connected to the tank car, the unit becomes practically automatic, requiring but little attention on the part of the operator. The new Cleaver continuous drainage system is the most outstanding feature of these new models. It keeps tank car coils bone dry and the manfacturer states that ordinarily less than a gallon of make-up water per hour is required. This new return condensate system brings water back into the boiler at practically steam temperatures, thereby saving fuel and at the same time, heating the material in the car much more rapidly than heretofore.

The 1938 Model Cleaver Tank Car Heater

▼

New Light-Weight Portable Compressors

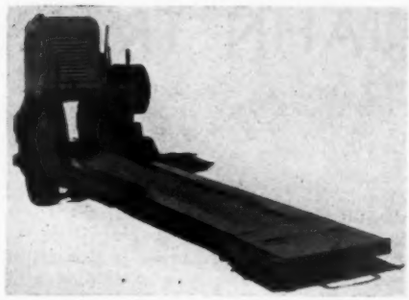
Three new light-weight models in its line of air-cooled portable compressors have recently been announced by the Ingersoll-Rand Co., 11 Broadway, New York. The smallest of these, the model 55, delivers 55 cu. ft. of air per minute at 80 lb. pressure; enough to operate a JA-30 Jackhamer, a dry JA-45 Jackhamer at 62 lb. or a CC-45 Paving Breaker. The next larger, the Model 85-A, delivers 85 cu. ft. of air per minute at 100 lbs. pressure; sufficient for operation of a JA-45 or a dry JA-55 Jackhamer or two CC-45 paving breakers. The largest of the three new models, the 105-A, is rated at 105 cu. ft. of air per minute at 100 lbs. pressure and will operate the largest dry Jackhamer or three paving breakers. These three newly styled light-weight mountings are designed for balance of weight and rigid construction throughout, permitting towing at speeds up to 35 miles per hour. Leaf-type spring mountings carry the machine on the running gear. Timken roller-bearing wheels are furnished with either pneumatic or solid rubber tires. Covers are hinged in the manner conventional for the engine hood of an automobile. Tool boxes built into the mounting provide a means of carrying "Jackhamers" and other tools. Air receiver and fuel tank are built end to end in the Models 85-A and 105-A for greater compactness and accessibility. Models 85-A and 105-A incorporate the famous I-R 2-stage, air-cooled compressor and are furnished with either gasoline or oil engine. The Model 55 compressor (3 cylinder) is single-stage, air-cooled and driven by a gasoline engine.

The New Ingersoll-Rand Light Weight Portable Compressors. Left to Right—Models 105-A, 85-A, and 55

▼

New Horizontal Car Unloader

A new car unloader so designed that it can be laid across the rails without having to dig into the ballast for a secure base for the machine has been brought out by the Atlas Conveyor Co., Clintonville, Wis. Placed underneath railroad hopper cars, the machine can be immediately started, and will maintain a steady, continuous conveying speed as long as material is fed onto the 18-in. belt. Designed simply, the machine is powered by a geared-head, 3 H. P., 60-cycle, 3-phase, 220-440 volts, AC electric motor. The unloader can be furnished with a 5 H. P., gasoline engine at the option of the purchaser. Complete specifications of this new car unloader include these features:



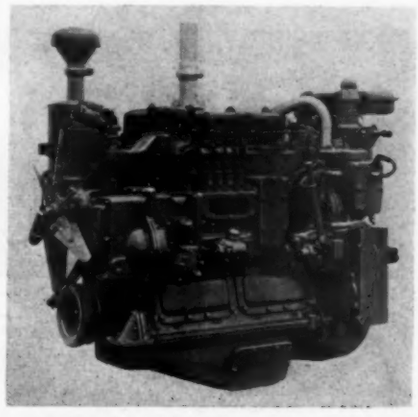
Model BU-18 Car Unloader

Length, overall, 13 ft., 9 ins; height, overall without power, 28 ins.; width, horizontal section, 21¾ ins.; width overall, 33 ins.; depth above rail, 3½ ins.; trough width, 11 to 15½ ins.; belt width, 18 ins.; belt, 28 oz. duck, with ⅛ 1-in. cover, and 1/32 in. bottom; power, either electric motor or gasoline engine; weight, with motor, 1,100 lbs; weight, with engine, 1,300 lbs.

▼

New 33-H.P. Diesel

Offering an industrial engine for the smaller power user, Caterpillar Tractor Co., Peoria, Ill., has announced the addition of the Diesel D3400 model to its current line. The new engine is a 4-cylinder model with 3¾ in. bore and 5-in stroke. It develops 33 H. P. at 1525 governed r.p.m. The D3400 engine is generally similar to other "Caterpillar" Diesels, featuring the 4-stroke cycle, valve in head, water cooled design, with solid fuel injection into precombustion chambers. Usually simple in design, the D3400 engine contains only three operating adjustments—the valves, water pump and fan. Fuel injection pumps and valves are factory set, and require no adjustment on the job. Seals and air cleaners insure ample protection, regardless of conditions. For quick, easy starting all conditions, a 10 H. P. power gasoline engine is used. A hot water manifold, on the front of the fuel filter housing, is another all-weather feature. This keeps the fuel oil at the proper temperature, regardless of climatic conditions. As a power unit, the engine also features a twin ra-



New "Caterpillar" Diesel D3400 Engine

NOW!

Built For Highway Mowing TORO ROUGHMASTER

The need of heavy, cumbersome farm or industrial tractors weighing upwards of three thousand pounds is over as far as mowing is concerned.

Note these specifications—

- a wheel base of only 71 inches.
- a turning radius of 6¾ feet.
- a speed range up to 15 miles per hour.
- a new improved sickle bar with a cutting range from 45° above to 40° below horizontal.
- controls that anyone can drive without special training.
- a normal life of ten years or more.
- a common sense low price.

There is a tremendous interest this year in Highway Mowers and the Roughmaster is the answer to the many requests for a light, strong, easily handled machine, and at a price that every State and County can afford.

Send for Interesting Circular

TORO MANUFACTURING CORPORATION

Minneapolis Minnesota

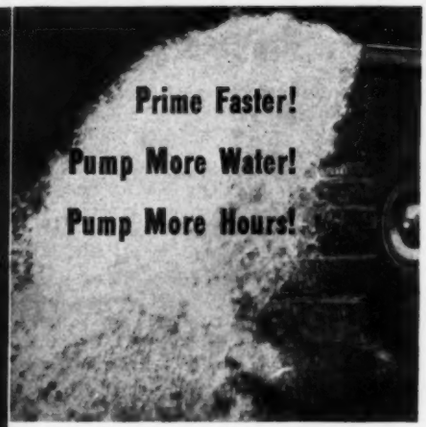
for LOWEST COST PER GALLON

$75 F.O.B Factory

JAEGER BANTAM 5200 G.P.H. Complete with Engine

COMPACT 2", 3", 4", 6" MODELS— 7,000 to 90,000 G.P.H.

8" and 10" Pumps, up to 220,000 G.P.H.

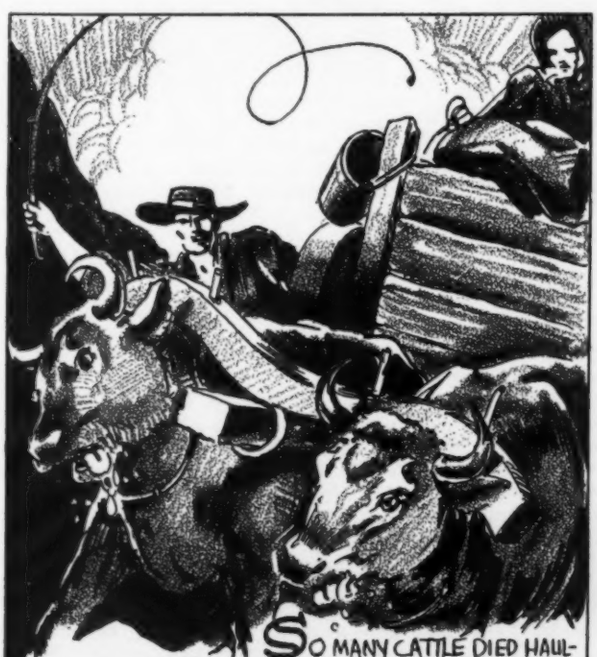


Use JAEGER Sure Prime Pumps

Only in a Jaeger do you get the Patented Priming Jet for fastest known 100% automatic prime, Patented Lubri-Seal for long-life, perfect sealing, Patented Self-Cleaning Shell and Jaeger Open Impeller for handling dirty water in maximum volume, without clogging or a sign of wear, thru thousands of hours of heavy service. Jobs are safer, dewatering costs lower with a Jaeger. Get our Catalog and Prices.

THE JAEGER MACHINE CO.
223 Dublin Ave., Columbus, Ohio

Did You Know That—



SO MANY CATTLE DIED HAULING FREIGHT OVER THE FRIGHTFUL TRAIL WHICH LED FROM PICKAWAY PLAINS, OHIO, TO DETROIT, IN THE EARLY 1800'S THAT THE HIGHWAY BECAME KNOWN AS "THE BULL-SKIN ROAD."

IN THE EXAGGERATED SPEECH OF THE DAY, THIS ROUTE WAS DESCRIBED AS BEING "LINED WITH THE HIDES OF DEAD CATTLE."

Paint Metal with
EAGLE
Sublimed
BLUE LEAD
STOPS RUST CHEMICALLY
COSTS LESS—PROTECTS LONGER
• Bloomfield Bridge, Pittsburgh, Pa.—protected from rust and corrosion with Eagle Sublimed Blue Lead—was repainted only once in 14 years! Yet Eagle Sublimed Blue Lead costs less per square foot of coverage than other rust-inhibitive paints. Meets Federal and A.S.T.M. specifications. Available in paste form. May also be secured from paint manufacturers by specifying Eagle Sublimed Blue Lead mixed to painting consistency.
EAGLE
EP
PICHER
THE EAGLE-PICHER LEAD COMPANY
CINCINNATI, OHIO

Kinney Reports 1938 Bituminous Distributor Sales Up 300%

To actually beat last year's sales record is NEWS. Yet such is the cheerful report which comes from the Kinney Mfg. Co., 3531 Washington Street, Boston, Mass.

W. E. Worcester, Vice-President in Charge of Sales, claims that sales to date bear out his earlier prediction that the new Kinney Bituminous Distributor, with the spray air-controlled from the cab, would make an immediate "hit" with Contractors looking with both eyes at possible ways of increasing their PROFIT.

Kinney is also featuring an alloy steel tank which takes 1,000 pounds off the weight —of a 1,000-gallon Distributor— another help toward more profit.

Kinney Engineers have wisely retained many popular features—the quick starting, ample pump capacity, efficient heating unit low in the tank, fuel tank well away from burners, ladders, hand-rails, relief valves and vents as safety features, etc.

Complete details are contained in Bulletin A-1938, being mailed by the Kinney Mfg. Co.

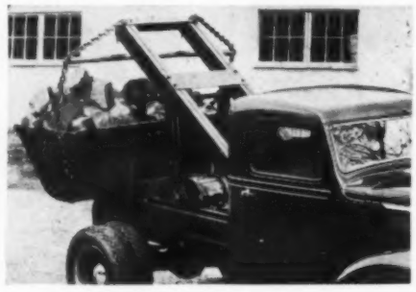
(Advertisement)

HERCULES
"TIRE PACK"
Carries Spare Tire
UNDER THE BODY
Compartment for Tools Flares Shovels
PATENTS APPLIED FOR
8 - FT. BODIES CAN BE CARRIED ON SHORT WHEEL BASE TRUCKS.
No Tire Mounting Problem!
Hercules puts the spare under the body — out of the way, saving approximately 11 inches between cab and body. Now 8 foot bodies replace 7 foot bodies with perfect load distribution.
Available only with the Hercules Super Power 16-T "Center Lift" Hoist.
Write for Literature
HERCULES STEEL PRODUCTS CO.
GALION, OHIO, U. S. A.
THE ONLY MANUFACTURERS OF A COMPLETE LINE OF DUMP BODIES

diator, which has been developed by "Caterpillar" engineers. One is for cooling the water, and the other for cooling the lubricating oil, thus assuring longer life for the main engine bearings.

The "Load Lugger"

A new piece of equipment—"The Brooks Load Lugger"—for hauling and transferring any material that is loaded by hand has been placed on the market by the Brooks Equipment & Mfg. Co., 408 Davenport Road, Knoxville, Tenn. It is stated that with it one truck alone can service 5 to 10 buckets, depending upon the material to be loaded and the distance hauled. No counterweight is required with the unit. It has direct drive from the power take-off to the hydraulic pump hoist assembly and requires no high pressure hose connections. The hoist used is hydraulic and positive in both up and down motions. The unit has no cables nor sheaves. The bucket is carried on the truck itself. The buckets have guides on the bottom that prevent sideway. The bucket, which is made in one piece, is stated to dump instantly, and, if desired, without leaving the truck. The "load lugger" may be shipped as a unit and easily mounted on any truck. The truck with the loaded bucket has a load distribution recommended as good practice by truck manufacturers and does not require cutting of springs, truck cross members, the adding of counterweights, etc.



The "Brooks Load Lugger"

New Design for Fluted Steel Pile Shells

In a revised catalog issued in April, the Union Metal Manufacturing Co. of Canton, Ohio, describes two new designs of steel shells for concrete piles.

These shells are of the fluted type, which is driven without the use of a core, or mandrel, and is left permanently in the ground. The flutings add substantially to the surface area, thus increasing friction and bearing capacity. Elimination of the core reduces inertia and makes driving easier. The flutings provide sufficient stiffness to prevent deformations under soil pressure.

Two important variations are made from the older design—the diameter of main section is reduced from 18 in. to 16⅜ in., and a much more gradual taper is provided at the bottom. The tapered fluted section has a bottom diameter of 8 in. in both old and new designs. Below this in each case is a cast point, or nose. But whereas the length from beginning of taper to tip of nose is 25 ft. in the old Type YN, it is 33 ft. in the new Type JN, and 63 ft. in the new Type FN for very long piles. Other tapers are made for special purposes.

The shells are made of steel plate—No. 11 gauge for most uses, but No. 7, No. 3, or No. 0 gauge where necessary. The longitudinal seam, the steel point, and all transverse joints are fully welded, so that the shell is water tight. Ordinarily each shell is constructed as a complete unit in whatever length may be required, but where necessary for shipping or other reasons, the shell may be provided in two or more lengths for field welding.

New Truck and Bus Tire

A new Silvertown truck and bus tire, its first line product for commercial service, has been announced by The B. F. Goodrich Co., Akron, O. The new tire is built with the recently announced Hi-Flex cotton tire cord, designed primarily to reduce tire heat generated in high speed service. A new tire building method, made possible by the new cord has been called the most revolutionary development in production since introduction of the cord tire into the United States by Goodrich in 1910.

So-called artificial stretch is removed befor the cord is built into the tire, resulting in a more compact, smaller-gauge product, which returns to its original position after being stretched. In building the tire by the new method, the manufacturer is able to use more rubber between cords. Slippage of fibers against each other is prevented, reducing friction and internal heat. The new tires are made with less overall thickness and yet with the same strength. Besides Hi-Flex cord, the new tire incorporates two time-tested Goodrich construction features, Ply-Flex, which distributes stresses throughout the tire and prevents local weaknesses, and Ply-Lock, which protects the short plies from tearing loose above the beads.

New Magneto

Fairbanks, Morse & Co., 600 S. Michigan Ave., Chicago, Ill., has announced the development of its new Type FM magneto. Full use has been made of Alnico, an aluminum-nickel-cobalt alloy in the Type FM magneto. Through field and laboratory tests extending over a period of two years, the entire design has been carefully adapted to the new magnets. This has not only increased power output, but reduced size and weight of the unit as well. The new design is similar to that of the widely used FM Type RV in that the Magnetic rotor is of die cast construction and the housing is aluminum alloy, die cast in one piece. The magneto is completely weatherproof. A totally sealing housing provides the protection against dust and moisture so essential to reliable engine performance, while suitable design and proper selection of materials assures operation under any temperature extremes. Service adjustments have been simplified. Changes in the breaker point supports permit quickly and

accurately setting the breaker point gap. Grease-packed ball bearings, which require no further attention, entirely eliminate all lubrication and bearing troubles. The distributor end cap has a built-in window, so that timing can be easily accomplished without removing the cap from the magneto.

WITH MANUFACTURERS

Strouse Gets New Post with Harnischfeger Corporation

The Harnischfeger Corporation of Milwaukee, Wis., manufacturer of traveling overhead cranes, excavators, etc., announces the recent appointment of H. S. Strouse as vice-president of the corporation. Along with the duties of his new position, Mr. Strouse will continue to direct the activities of the treasurer's department which he has headed for the past seven years. In taking over his new post, Mr. Strouse reaches a

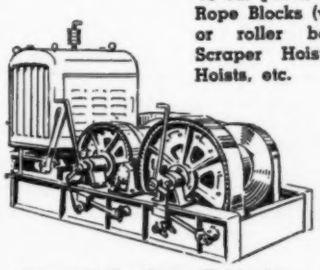
H. S. Strouse

new high point in his 23 years of business activity which began in 1915 when he graduated from the school of Electrical Engineering at Purdue University. After graduation, he entered the Chicago Central Station Institute for approximately a year, following which he was employed by the Interstate Public Service Company at Newcastle, Ind., as new business manager. At the outbreak of the war he entered the first officers' training camp at Fort Benjamin Harrison, Indianapolis, and; after active service overseas, with the 310th Regiment of Engineers, was mustered out in 1919. Mr. Strouse then entered the employ of the Western Electric Co. at Chicago as designer in the automatic telephone section. Shortly after this he went to the Harnischfeger Corporation of Milwaukee as estimating engineering. In 1921 he was appointed to the position of advertising manager, and in 1931 was elected treasurer of the company. Two years later he became a director of the company. Mr. Strouse's experience in all departments of the Harnischfeger Corporation—engineering, advertising, and financial—has been an invaluable aid to his organization and well qualifies him for the duties of his new position.

Scraper Bucket

Slackline Bucket

"Durolite" All-Steel Wire Rope Blocks



Improved Two-Drum Hoists for Drag Scraper and Slackline Operating Duty

SAUERMAN LONG RANGE MACHINES

For Digging, Conveying, Stockpiling

For larger profits on long range excavating and material handling work, use a Sauerman Drag Scraper, Slackline, or Tower Machine. A Sauerman machine is able to span an area 1,000 ft. or more in width and convey materials from any point in this area at a rapid rate. One man handles the entire operation.

The sizes of Sauerman machines range from portable units for small pit operations up to huge machines with capacities approaching 1,000 cu. yd. per hour. There is a special type for underwater excavation, another for digging from a bank, another for storing and reclaiming, and so on.

In addition to the complete Sauerman machines, we offer also the various types of Sauerman buckets in sizes from ¼ cu. yd. to 15 cu. yd., "Durolite" Wire Rope Blocks (with either bronze bearings or roller bearings. Roller Bearing Scraper Hoists, Two Speed Slackline Hoists, etc.

Write for 84-page general catalog

SAUERMAN BROS.

488 S. CLINTON ST.

CHICAGO, ILLINOIS

Slackline lifts sand from bottom of bay to top of plant.

Moving gravel from hill to crusher with drag scraper.

Fritz Awalt Now Pacific Coast Sales Manager for Foote Co.

The Foote Company, Inc., of Nunda, N. Y., announces the appointment of F. M. "Fritz" Awalt as Pacific Coast District Sales Manager. Mr. Awalt has an excellent record in the sale of heavy equipment. He was for several years sales agent for the Waukesha Engine Co. of Milwaukee, and was later directly connected with Waukesha in handling the sales of Waukesha engines on the Pacific Coast. From the Waukesha Company, Mr. Awalt went directly to the Northwest Engineering Co. where he handled the sale of Northwest shovels, cranes and draglines in the Chicago territory. Mr. Awalt will have complete charge of the Pacific Coast sales organization in ten western states for The Foote Company, who manufacture Multi-Foot concrete pavers, Adnun black top pavers, and Adnun spreaders.

▼

Sullivan Machinery Company Moves

The Sullivan Machinery Co., makers of air and gas compressors, core drills, oil field drills, oil well pumps, rock drills, hoists and coal mining machinery has moved their general offices from 307 North Michigan Ave., Chicago, Ill., to Michigan City, Ind. The Chicago Sales Office will remain at the Chicago address. The company operates plants in Michigan City, Ind., and Claremont, N. H., with additional manufacturing facilities in Dundas, Ont., Canada, and Grantham, England.

Barber-Greene Appoints New Distributors

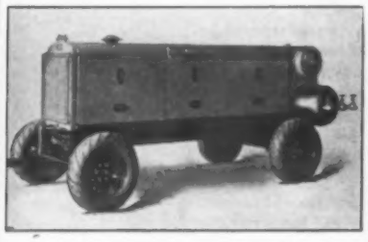
E. F. Lamprey, for many years with Barber-Greene Co., Aurora, Ill., and for the past few years sales manager of a machinery house in the Boston territory, has rejoined the Barber-Greene Sales Organization. He will work with Messrs. Ford and Caywood in the Boston Office, with headquarters at 84 Rogers St., Cambridge, Mass. W. B. Holder is Eastern Sales Manager. The following distributors have been appointed recently to handle the Barber-Greene account in their respective territories: A. R. Amos, Jr., Commercial Trust Bldg., Philadelphia, Pa. Columbia Equipment Co., headquarters at Portland, Ore., with branches in Spokane and Seattle, Wash., Baker, Ore., and Boise, Idaho. W. T. Jones Co., Dooly Bldg., Salt Lake City, Utah, will sell mining, smelting, and other equipment purchased by manufacturers. The Lund Machinery Co. continues to represent Barber-Greene in this territory on contracting, sand and gravel handling, etc., equipment. A. E. Hunt, 1115 Burnaby St., Vancouver, B. C., Canada. J. Shuman Hower, 85 North Genesee St., Utica, New York.

▼

Beatty Advanced by Inland Steel

Inland Steel Co., Chicago, Ill., has announced the appointment of Howard W. Beatty as assistant manager of sales for rail steel and reinforcing bars. Mr. Beatty was formerly in the operating division of

OK AIR COMPRESSORS



● OK Compressors are made in a full range—in both single and two stages; gasoline, diesel and electric driven.
High Compressor efficiency, high drilling speed, dependability and low maintenance cost—have proven to extensive users in U. S. Government, States, Municipalities, Counties & Contractors, the outstanding superiority of OK Air Compressors.

O. K. CLUTCH & MACHINERY COMPANY
Columbia, Pennsylvania

one of the large Kentucky coal companies. However, he has been associated with the Inland Steel Co. for the past 16 years. He was originally in various divisions of the order department and since 1933 has been in the Rail Steel and Reinforcing Bar division of the Sales Department.

▼

Barber Co. Changes Name

Stockholders of The Barber Company, Inc., 1600 Arch St., Philadelphia, Pa., at the annual meeting held April 27, approved a change in the corporation's name to Barber Asphalt Corporation.

▼

George D. Shaeffer Joins Gar Wood

Jack B. Haile, general manager of the road machinery division of Gar Wood Industries, Inc., Detroit, Mich., has announced the recent appointment of George D. Shaeffer to the position of chief engineer of that division. Mr. Shaeffer was chief engineer for the past eleven years, of the road machinery division of the W. A. Riddel Corporation Bucyrus, Ohio. He was also with the Allis-Chalmers Manufacturing Co.'s road machinery division, for several years. Products manufactured by the Gar Wood road machinery division include rip rooters, tamping rollers and hydraulically-operated scrapers, bulldozers and road-builders, which have figured prominently in the construction of the nations, highways and projects such as dams, canals and airports.

G. D. Shaeffer

▼

R. G. Hext New Advertising Manager of Littleford Bros.

Littleford Bros. of Cincinnati, O., announce the appointment of Richard G. Hext to the position of Advertising Manager. Although Mr. Hext is a newcomer in the highway industry, he brings to his new connection a background of fifteen years of advertising experience, having been with Procter and Collier Advertising Agency and more recently with the A. S. Boyle Company. Mr. Hext is a native of Cincinnati and in recent years was located in Chicago and Jersey City, N. J.

R. G. Hext

▼

Herron Now Manager New Los Angeles Branch of Independent Pneumatic

The Independent Pneumatic Tool Co. of Chicago, Ill., has announced the opening of a new sales-service branch at 6200 E. Slauson Ave., Los Angeles, Calif. The new office will be in charge of Mr. B. J. Herron. Mr. Herron started with the company eighteen years ago as a salesman in Pittsburgh and for the past twelve years has been a general representative in the western section of the United States.

▼

G. E. Officers Re-elected

At the meeting of the board of directors of the General Electric Co. on April 22, Owen D. Young was re-elected chairman of the board and Gerard Swope president of the company. All other officers of the company were also re-elected.

▼

Burke Elected Vice President of Koppers

K. R. Burke, general superintendent of Koppers Company's Tar and Chemical Division, has been elected a vice president of the company at a meeting of Koppers Company directors. Mr. Burke has been general superintendent of the company's tar and chemical operations since 1928. He formerly was associated with the American Tar Products Company, and came to Koppers when that company was acquired in 1925. Plants of the Tar and Chemical Division are located at Buffalo, N. Y.; South Milwaukee, Wis.; Cicero, Ill.; Everett, Mass.; Follansbee, W. Va.; Hamilton, O.; New Haven, Conn.; East Providence, R. I.; Kearny, N. J.; St. Louis, Mo.; St. Paul, Minn.; Utica, N. Y.; Woodward, Ala., and Youngstown, O.

▼

New Representatives for Ransome

The Ransome Concrete Machinery Co., Dunellen, N. J., manufacturers of a complete line of concrete mixers has appointed The West Virginia Co., of Charleston, W. Va., and Constructors Supply Co., Durham, N. C., as representatives for their complete line of equipment in that territory. In line with their new sales expansion policy they have also added to their present large selling force in Canada the Standard Machinery & Equipment Co. Ltd., 52 Germain St., St. John, New Brunswick, Canada, to handle their concrete mixers up to and including the new 5-S model. All other sizes will be, as at present, handled by Canadian Fairbanks-Morse Co.

▼

Watson Now Assistant Manager of Sales, Chicago District, for Carnegie-Illinois

Carnegie-Illinois Steel Corporation, Pittsburgh, Pa., has announced the advancement of T. Lane Watson to the position of Assistant Manager of Sales, Chicago District, effective May 1. Mr. Watson has a continuous record of service with United States Steel Corporation subsidiaries since he was employed by the former Carnegie Steel Co. at Pittsburgh in 1910. He has served in executive positions in the Pittsburgh and Cleveland sales offices and since November, 1936, has served in Chicago in charge of the Bar, Strip and Semi-finished Materials Division.

▼

Andrews Now Sales Manager, Cincinnati District Carnegie-Illinois Steel

The appointment of William P. Andrews as Manager of Sales, Cincinnati District, effective May 1, was announced April 26 by Carnegie-Illinois Steel Corporation. Mr. Andrews, now Assistant Manager of Sales, Chicago District, assumes the position made vacant recently by the death of Lawrence K. Slaback of Cincinnati. Mr. Andrews has a 17-year service record with United States Steel Corporation subsidiaries which began in 1921 when he was weighmaster at the Gary Tin Mills of the former American Sheet & Tin Plate Co. He spent two years as a sales student following which he was appointed a sales representative in the New York office. Later he served in the same capacity in Chicago and Minneapolis and in June, 1934 was appointed Assistant Manager of Sales in the Chicago District.

New Holland
Jaw, Hammer & Roll Crushers • Revolving & Vibrating Screens • Conveyors, etc.
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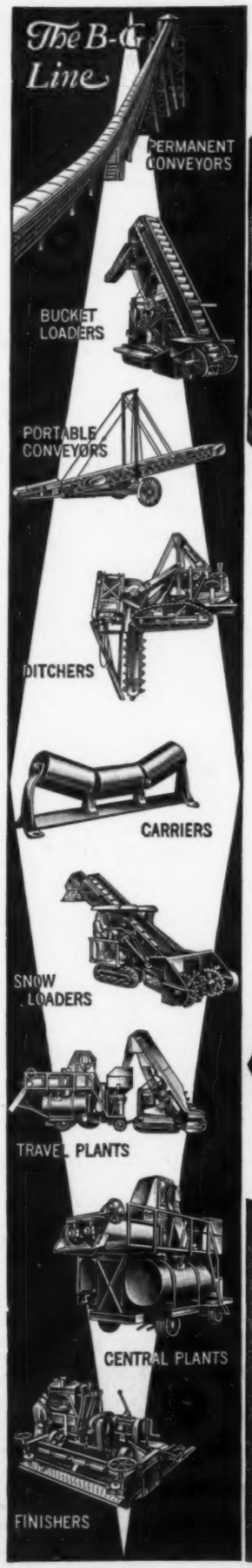

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It will pay you to investigate the Barber-Greene Bucket Loader.

Just ask for Bulletin 82, there is no obligation.

Also ask for our new 52 page booklet "Good Roads" which shows the complete line of Barber-Greenes for contracting.

•

THE primary advantage of the Bucket Loader is simple—it is the cheapest means of loading bulk material. It will probably pay for itself even though you have other equipment now being used for loading. It is generally regarded as one of the most valuable tools for contracting. In addition to low cost, high capacity loading, it is advantageously used for screening, stripping, light excavating, accurate grading, backfilling, etc.

The B-G 82A Bucket Loader is an outstanding achievement in equipment design. Synchronized Feeding gives higher capacity with less power consumption; the Automatic Overload Release protects the machine, eliminates delays; Slow Crowding Speed gives easier, more efficient operation; Fast Traveling Speed saves money and time; Tank Type Chassis Frame gives greater strength, and encloses all driving mechanism; Floating Boom allows crowding thrust to go direct from crawlers to feeding end; the Full Crawler Mounting gives maneuverability that saves time on every move; and the B-G Snow Loader boom can be mounted on the same chassis.

Standardized Material Handling Machines

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ROADS and STREETS

With which have been merged GOOD ROADS and ENGINEERING & CONTRACTING

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WRITE for our new circular showing illustration and description of Olsen Special Bench Type Compression Testing Machine. It is designed especially for testing 2" x 4" cylinders and 2" x 2" cubes. The machine is hydraulic, having two gauges, one to half and the other to full capacity. Capacity ranges of from 20,000 to 80,000 lbs.

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